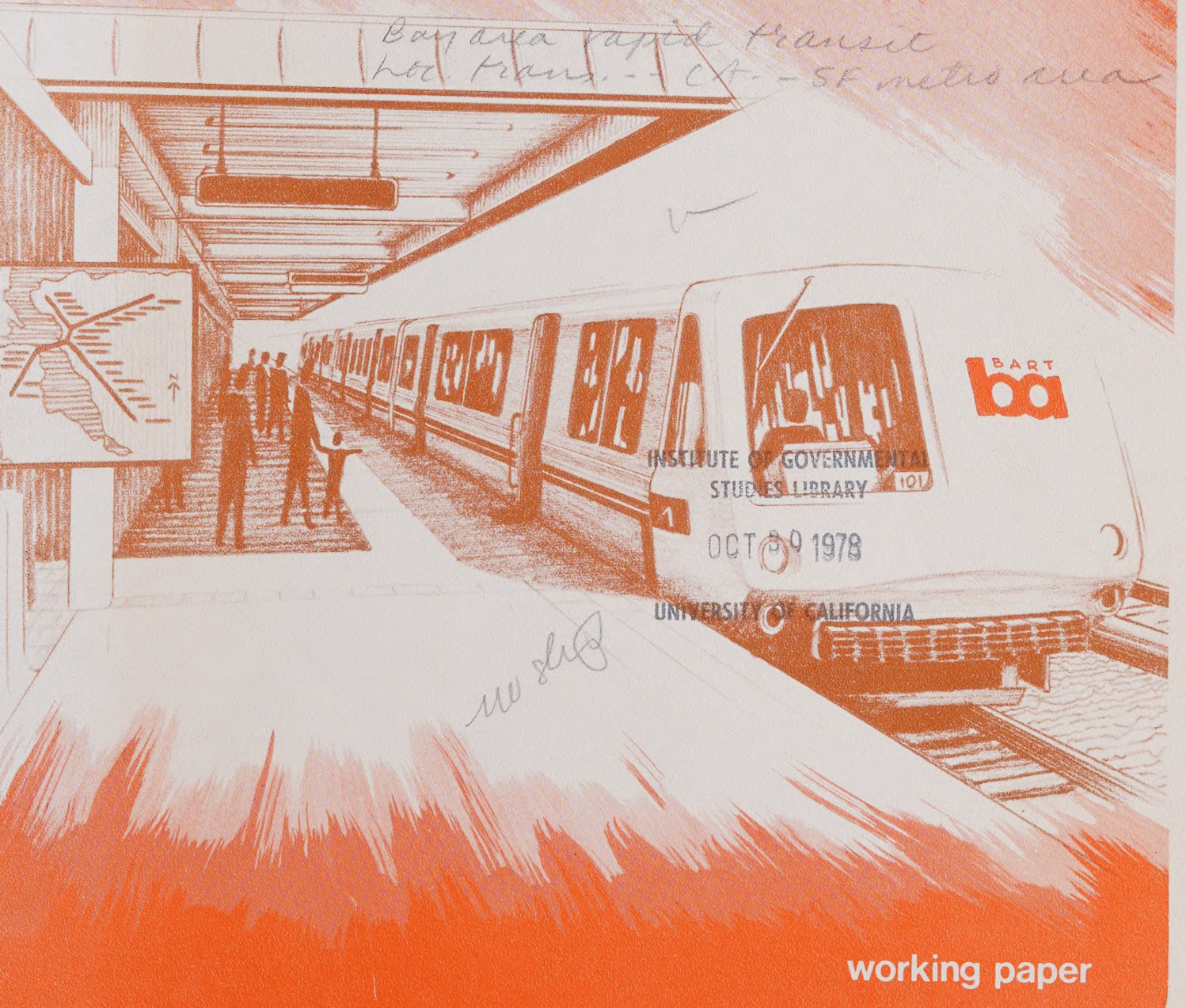
bart
impact
program

A DESCRIPTION OF BART: ITS FACILITIES, SERVICE AND SURROUNDINGS



working paper

The BART Impact Program is a comprehensive, policy-oriented study and evaluation of the impacts of the San Francisco Bay Area's new rapid transit system (BART).

The program is being conducted by the Metropolitan Transportation Commission, a nine-county regional agency established by state law in 1970.

The program is financed by the U. S. Department of Transportation, the U. S. Department of Housing and Urban Development, and the California Department of Transportation. Management of the Federally funded portion of the program is vested in the U. S. Department of Transportation.

The BART Impact Program covers the entire range of potential rapid transit impacts, including impacts on traffic flow, travel behavior, land use and urban development, the environment, the regional economy, social institutions and life styles, and public policy. The incidence of these impacts on population groups, local areas, and economic sectors will be measured and analyzed. Finally, the findings will be interpreted with regard to their implications for the planning of transportation and urban development in the Bay Area and other metropolitan areas.

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BART IMPACT PROGRAM

A DESCRIPTION OF BART: ITS FACILITIES, SERVICE AND SURROUNDINGS

PREPARED BY
GRUEN ASSOCIATES, INC.

UNDER CONTRACT WITH THE
METROPOLITAN TRANSPORTATION COMMISSION

FOR THE
U. S. DEPARTMENT OF TRANSPORTATION

AND THE
U. S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

UNDER
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This report provides an overview of the BART system within its Bay Area setting. The planning, design and construction of the system are described here, as are its physical facilities, operations, and management. Physical and social characteristics of the nine-county San Francisco Bay Area, the primary BART service area (Contra Costa, Alameda, San Francisco and northern San Mateo counties) and the immediate surroundings of the system are discussed, and the populations within those areas are defined. Data is presented here without analysis or evaluation and is intended to serve as background and perspective for viewing the various studies within the BART Impact Program.

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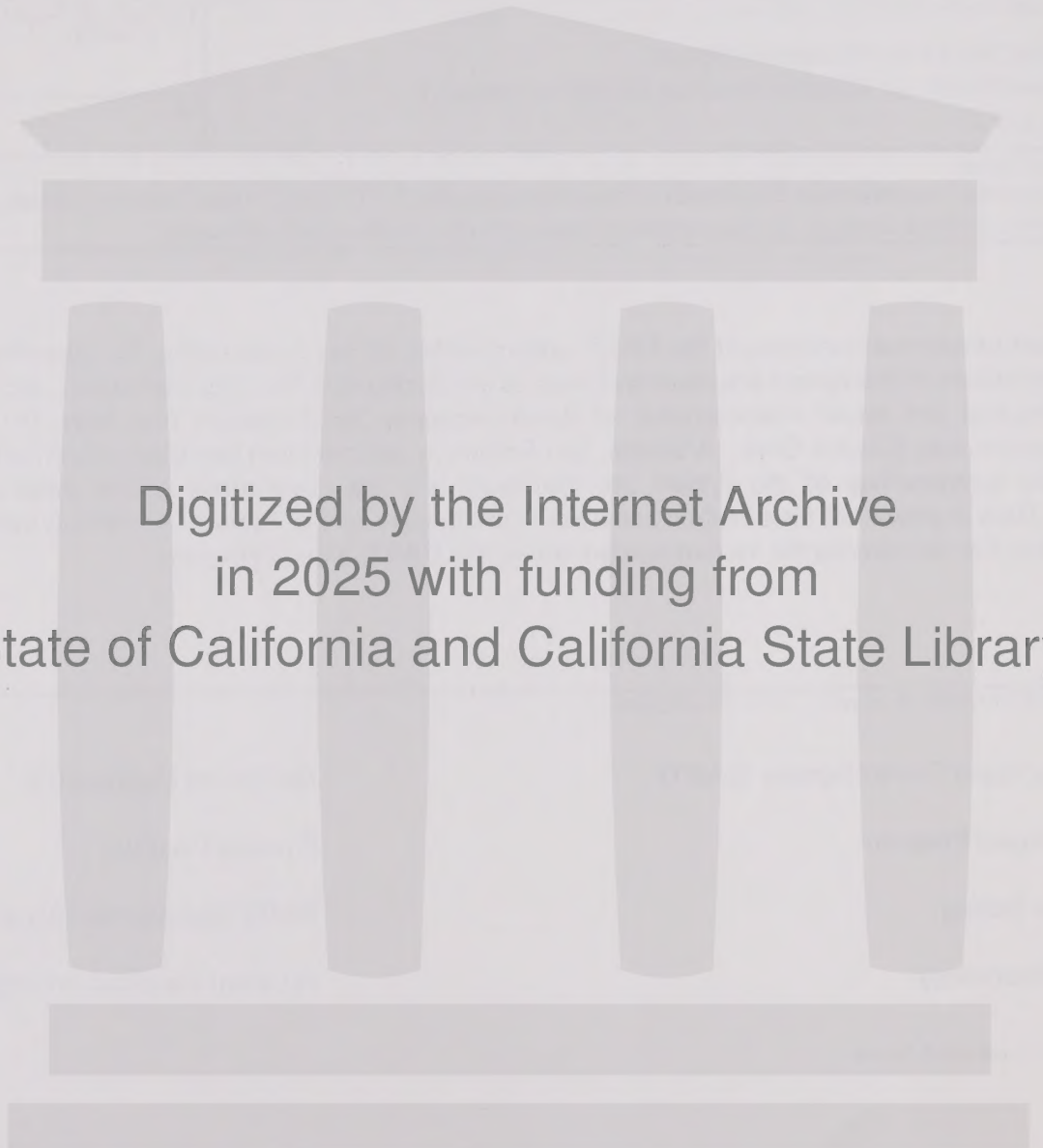

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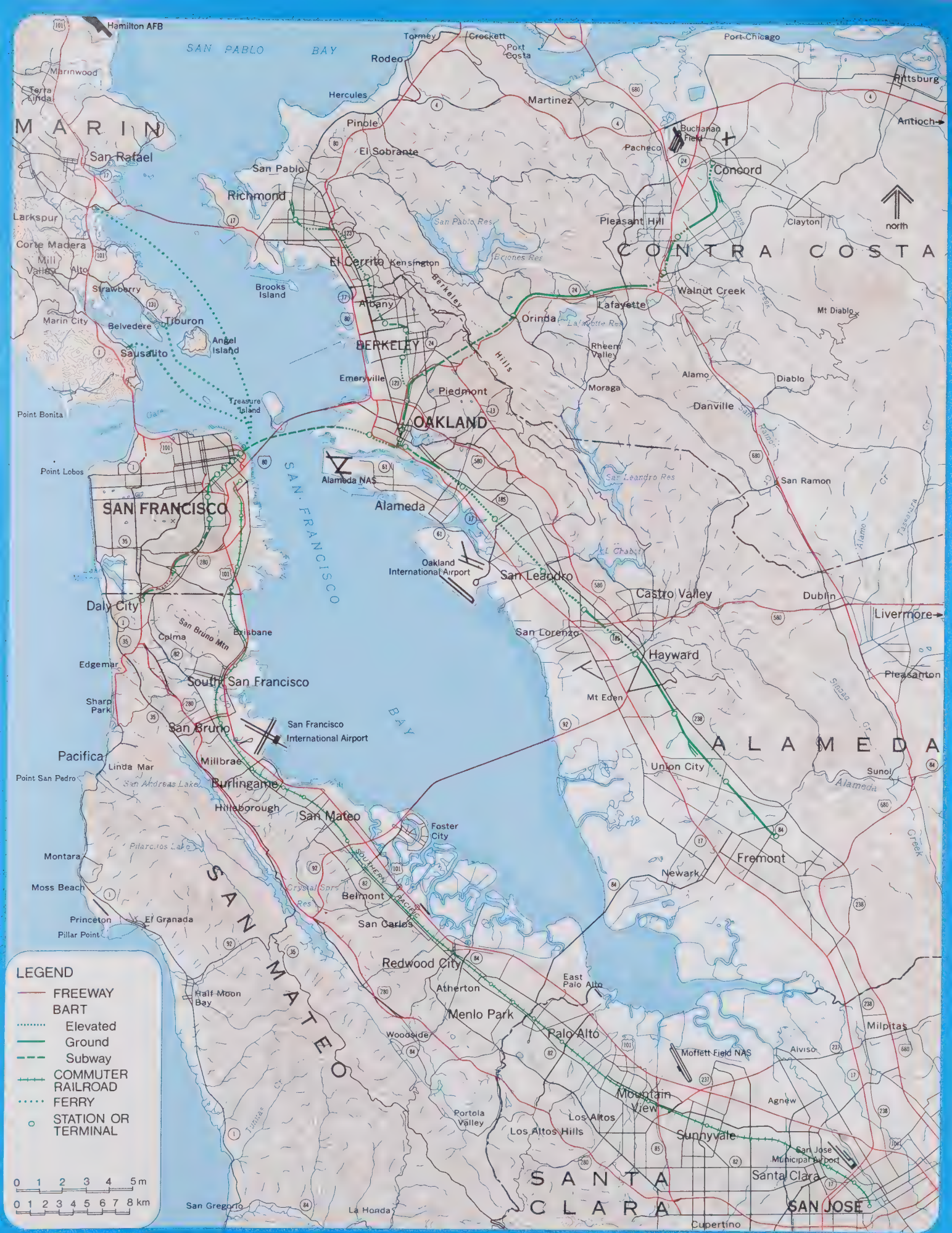

SAN FRANCISCO BAY REGION

CENTRAL AREA

BART: The Bay Area Rapid Transit System

Length: The 71-mile system includes 20 miles of subway, 24 miles on elevated structures and 27 miles at ground level. The subway sections are in San Francisco, Berkeley, downtown Oakland, the Berkeley Hills Tunnel and the Transbay Tube.

Stations: The 34 stations include 13 elevated, 14 subway and 7 at ground level. They are spaced at an average distance of 2.1 miles: stations in the downtowns are less than one-half mile apart while those in suburban areas are two to four miles apart. Parking lots at 23 stations have a total of 20,200 spaces. There is a fee (25 cents) at only one of the parking lots. BART and local agencies provide bus service to all stations.

Trains: Trains are from 3 to 10 cars long. Each car is 70 feet long and has 72 seats. Top speed in normal operations is 70 mph with an average speed of 36 mph including station stops. All trains stop at all stations on the route.

Automation: Trains are automatically controlled by the central computer at BART headquarters. A train operator on board each train can override automatic controls in an emergency.

Magnetically encoded tickets with values up to $20 are issued by vending machines. Automated fare gates at each station compute the appropriate fare and deduct it from the ticket value. At least one agent is present at each station to assist patrons.

Fares: Fares range from 25 cents to $1.45, depending upon trip length. Discount fares are available to the physically handicapped, children 12 and under, and persons 65 and over.

Service: BART serves the counties of Alameda, Contra Costa and San Francisco, which have a combined population of 2.4 million. The system was opened in five stages, from September, 1972, to September, 1974. The last section to open was the Transbay Tube linking Oakland and the East Bay with San Francisco and the West Bay.

Routes are identified by the terminal stations: Daly City in the West Bay, Richmond, Concord and Fremont in the East Bay. Trains operate from 6:00 a.m. to midnight on weekdays, every 12 minutes during the daytime on three routes: Concord-Daly City, Fremont-Daly City, Richmond-Fremont. This results in 6-minute train frequencies in San Francisco, downtown Oakland and the Fremont line where routes converge. In the evening, trains are dispatched every 20 minutes on only the Richmond-Fremont and Concord-Daly City routes. Service is provided on Saturdays from 9 a.m. to midnight at 15-minute intervals. Future service will include a Richmond-Daly City route and Sunday service. Trains will operate every six minutes on all routes during the peak periods of travel.

Patronage: Approximately 142,000 one-way trips are made each day. Approximately 200,000 daily one-way trips are anticipated under full service conditions.

Cost: BART construction and equipment cost $1.6 billion, financed primarily from local funds: $942 million from bonds being repaid by the property and sales taxes in three counties, $176 million from toll revenues of transbay bridges, $315 million from federal grants and $186 million from interest earnings and other sources.

March 1978

SUMMARY

Introduction

This report presents a description of BART, its design and construction, its facilities and operations and the environment of which it is a part. The report is intended to provide background for considering the findings of the various studies within the BART Impact Program. The data presented here was compiled from a number of sources, including BART, the Metropolitan Transportation Commission, BART Impact Program studies and other publications.

Bay Area Setting

The nine counties of San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Napa, Sonoma and Marin constitute the Bay Area. These counties cover a total of 7,500 square miles, of which 7,000 square miles are land.

The major geographic feature of the area is San Francisco Bay, which is bordered by a band of flatlands and virtually surrounded by chains of coastal mountains. Rolling hills and valleys are typical of the inland areas. In the nine-county area there are 1,360 square miles of useable land, of which 51 percent is developed. Of the three counties traversed by BART, San Francisco is the most fully developed, with 97 percent of its useable area in urban uses, while 71 percent of Alameda County and 47 percent of Contra Costa have been developed.

The 1975 population of the Bay Area is estimated to be 4,829,200. Forty-nine percent of the area's population lives in the three counties where BART is located: 23 percent (1,089,900) in Alameda County, 14 percent (672,600) in San Francisco County and 12 percent (582,800) in Contra Costa County. Projections to 1990 suggest that the Bay Area's population will grow by 9 to 16 percent over the 1975 population. The population of Alameda County is expected to grow by 7 to 8 percent and that of Contra Costa County by 19 to 33 percent, while the population of San Francisco is expected to decrease by 5 to 6 percent.

It is estimated that a total of two million persons were employed in the Bay Area in 1975. Fifty-three percent of these were employed in the three BART counties: 495,400 (24 percent) in San Francisco County, 434,300 (21 percent) in Alameda County and 160,100 (8 percent) in Contra Costa County. Employment projections to 1990 for the Bay Area suggest a 15 to 25 percent increase over 1975 employment figures. In San Francisco County, employment is expected to grow by 15 to 20 percent during that period, while employment growth is projected at rates of 18 to 33 percent for Contra Costa County and 11 to 17 percent for Alameda County.

Approximately five million vehicle trips are made in the BART service area (Alameda, Contra Costa and San Francisco Counties) during each weekday. About 87 percent of these trips are made by automobile, with public transit accounting for 13 percent of the trips.

BART Chronology

Major events in the planning, design, construction and operation of the BART system occurred during the years 1962 through 1974, as follows:

May 1962	Three-county rapid transit plan adopted by BART Board.
November 1962	$792 million bond issue approved by voters.
July 1963	Full-scale design and engineering began.
June 1964	Construction began.
September 1972	First line segment (Fremont line) opened for revenue service.
January 1973	Richmond line opened.
May 1973	Concord line opened.
November 1973	Daly City line opened to downtown San Francisco.
September 1974	Transbay Tube became the last major line segment opened for service.

Design and Construction

Management of BART's design, engineering and construction was the responsibility of a three-firm joint venture (PBTB): Parsons, Brinckerhoff, Quade and Douglas; Tudor Engineering; and Bechtel Corporation. The BART Board and a small staff provided overview of the process. BART cars were assembled by Rohr Corporation, and the automatic train control (ATC) system was designed and ins talled by the Westinghouse Corporation. Stations were designed by 15 different Bay Area architects.

System construction was planned to take six years; actually, 11 years were spent building the system. Longest periods of construction were required for downtown subway stations (30 to 36 months), while shortest construction periods (about 2 months) were for aerial line segments. Suburban stations, all of which are above ground, averaged 24 months in construction.

Over 922 acres in 3,482 parcels of land were taken for system facilities. About 3,000 dwelling units and 7,200 persons were displaced.

Total forecast capital costs for the completed BART system are $1,635,600,000. About 40 percent of these costs are for track and track structures, 20 percent are for stations, 10 percent are for vehicles, and 8 percent are for engineering and management. The remaining costs (about 20 percent) are pre-operating expenses and costs of right-of-way, train control, electrification, utility relocation, and yards and shops for equipment maintenance. Nearly 60% of the funds for BART's capital costs came from the sale of general obligation bonds. A relatively small amount (about 20 percent) came through Federal capital grants; sources for most of the remainder of the capital funds are bridge tolls, sales taxes and temporary investment earnings.

Physical Facilities

BART lines radiate from central Oakland to four terminal stations: Daly City in the West Bay and Richmond, Concord and Fremont in the East Bay. The East Bay is connected with the West Bay by a 3.6-mile tube along the floor of the Bay between Oakland and San Francisco. Seventeen of the system's 34 stations are in Alameda County, eight are in Contra Costa County, eight are in San Francisco County and one is in northern San Mateo County.

The system has 71 miles of trackway in three basic configurations: Aerial (24 miles), at-grade (27 miles), and below ground (20 miles). Of its 34 stations, 20 are above ground and 14 are below.

There are three main components within each station: An entranceway, a mezzanine and a platform. Subway stations are entered from the street by stairs, escalator or elevator; above-ground stations are entered at street level. The mezzanine provides space for the ticketing and fare collection process, the station agent, informational signs and passenger amenities. The platform is on another level, reached from the mezzanine by stairway, escalator or elevator; passengers board and exit trains in the platform area.

Bus service to BART stations is provided primarily by Alameda-Contra Costa Transit District (AC) in the East Bay and San Francisco Municipal Railway (MUNI) in the West Bay. Although AC and MUNI are organizationally and financially separate from BART, reduced-fare transfers are available to BART riders using AC or MUNI to complete their trips.

Twenty-three of BART's 34 stations have parking facilities ranging in capacity from 197 spaces to 1,627 spaces. Total systemwide parking capacity is 20,128 spaces. Parking is free at all lots except Lake Merritt, where a 25-cent charge is made. Each lot provides areas for all-day parking, midday parking, auto passenger drop-offs and pick-ups and special stalls for handicapped patrons.

Service facilities for the system include three yard areas for vehicle inspection, servicing and storage. These range in size from 20 to 50 acres and operate 24 hours a day, seven days a week.

BART Operational Features

BART train vehicles are of two types. Cars with attendants' cabs and automatic train control equipment are at both ends of each train for reversible operation. Between them are shorter cars which have no train control equipment. Each car is powered by four 150-horsepower motors, mounted one to each axle. Trains use propulsion power from a 1,000-volt direct current third rail. The vehicles are equipped with a dynamic braking system and a friction braking system. The propulsion motors are used as generators to return power to the third rail during braking.

Each car seats 72 passengers, with standing room for about twice that number. Seats are foam padded, and cars have wall-to-wall carpeting. A multi-zone air conditioning system controls temperature and humidity. Doors to station platforms open automatically for passengers exiting and boarding trains. A public address system is used by the attendant to announce stations.

An automatic train control (ATC) system dispatches and routes trains, regulates their speeds, maintains safe distances between them and controls station stops. ATC components include a central computer control complex, 36 local train control centers, control equipment on vehicles and an information relay system. To ensure safety, four back-up control systems have been or are being implemented.

BART trains operate between 6:00 a.m. and midnight Monday through Friday and between 9:00 a.m. and midnight Saturday, with Sunday service scheduled to begin in mid-1978. Direct service between Richmond and Daly City is scheduled to begin in 1978. Operating headways are currently 6 to 12 minutes during the day and 20 minutes during evening hours. Thirty-three trains from 3 to 10 cars in length are operated each day. Normal maximum operating speed is 70 miles per hour, with an average speed of 32 miles per hour.

Currently, 130-140,000 trips per day are served by BART; individual station patronage ranges from 1,200 to 17,000 fares per day. BART serves 2.4 percent of all weekday vehicular trips made in the BART service area, 5.2 percent of all work trips and 21 percent of the work trips between the East Bay and San Francisco.

About 52 percent of the trips on BART are made during the morning and afternoon peak periods; these are primarily work trips to downtown San Francisco. The average ride is 13 miles long; the trip takes 46 minutes door to door. Fares range from $0.25 to $1.45, according to distance traveled. Reduced fares are available for children, handicapped persons and the elderly.

BART ridership includes a high proportion of persons between the ages of 18 and 34, and BART riders tend to be more highly educated than the general population. The average income of BART riders is similar to that for the region as a whole, and proportions of racial/ethnic groups are similar to regional proportions, except that BART riders include fewer persons of Spanish heritage.

For all trips, about 50 percent of BART's patrons arrive at stations by automobile. The number of persons using autos for BART access varies significantly according to time of day and station location. Auto access is greatest during the morning peak hours at suburban stations, while downtown stations have greater access by bus and walking throughout the day. Twelve of BART's 23 parking lots are filled daily, and there is substantial on-street parking by BART patrons near seven stations, five of which have parking lots. Parking problems are most serious at stations near the extremities of BART lines.

The rate of accidents within the BART system has been declining since 1973; there have been no passenger deaths or serious injuries and few legal claims against the BART District. The total number of accidents in fiscal year 1976-77 was 682, representing 19.71 accidents per million passenger trips or 1.51 accidents per million passenger miles. The greatest number of crimes within the system is incidents of fare evasion, vandalism and auto theft, with few crimes against persons. During fiscal year 1976-77, there were 4,235 crime reports, amounting to 122 crimes per million passenger trips or 9.4 per million passenger miles.

Currently, BART uses an average of 0.47 kilowatt hours of electrical energy for each passenger-mile of travel. Seventy-one percent of this is for traction and 29 percent is for other BART operations (e.g., stations, yards, maintenance shops). The trend in BART energy use per passenger-mile and per vehicle-mile has been downward; between 1973 and 1976 the number of passenger-miles quadrupled and the number of vehicle-miles tripled, while BART energy use increased only 86 percent.

Operating costs during fiscal year 1976-77, including $3 million of capitalized operating expenses, were $70 million; 47 percent of these costs were for maintenance, 25 percent for transportation, 17 percent for general and administrative functions, 8 percent for construction and engineering and 3 percent for police services. Fare revenues meet 35 percent of the operating costs. Other sources of operating funds include sales taxes (45 percent), property taxes (8 percent), construction funds (5 percent), financial assistance (5 percent) and investments (2 percent).

Adjacent Land Use and Population

Of the 71 miles of BART trackway:

- 19 miles (27 percent) run through suburban residential areas;
- 18 miles (25 percent) are in urban residential areas;
- 15 miles (21 percent) go through areas of open land and water;
- 11 miles (16 percent) traverse industrial/commercial areas;

5 miles (7 percent) are within small downtown and commercial sub-center areas; and
3 miles (4 percent) lie within central downtown areas.

Nearly 85 percent of the BART trackway is within or beside the right-of-way of another major transportation facility (railroad, arterial or freeway).

Near BART stations and lines (i.e., within one-quarter to one-half mile) the highest population densities are in downtown Oakland and San Francisco. Segments of BART line pass through areas which have concentrated Black populations (e.g., along the Richmond line) and Spanish-heritage populations (e.g., along the Daly City line). Near BART stations in downtown San Francisco and Oakland, over 20 percent of the nearby residents are elderly. Family incomes under $12,000 are typical along all BART lines except the Concord line, where incomes are considerably higher.

I. INTRODUCTION

Purpose and Scope

The purpose of this report is to provide an overview of the BART system within its Bay Area setting. The planning, design and construction of the system are described here, as are its physical facilities, operations and management. Physical and social characteristics of the nine-county San Francisco Bay Area, the primary BART service area (Contra Costa, Alameda, San Francisco and northern San Mateo Counties) and the immediate surroundings of the system are discussed, and the populations within those areas are defined. Data is presented here without analysis or evaluation and is intended to serve as background and perspective for viewing the various studies within the BART Impact Program.

The BART Impact Program is a comprehensive, policy-oriented study and evaluation of the impacts of the BART system. It covers the entire range of possible rapid transit impacts and includes major impact studies of the Bay Area's transportation systems, travel behaviors, land use and urban development, the environment, the regional economy, social institutions and lifestyles, and public policy. The impacts are defined, then measured and analyzed by their effects on population groups, local areas and economic sectors. Finally, the findings will be interpreted with regard to their implications for the planning of transportation and urban development in the Bay Area and other metropolitan areas.

Data Sources

Most of the material presented here was adapted from information supplied by the BART District and from various reports compiled by and for the Metropolitan Transportation Commission (MTC), the Association of Bay Area Governments (ABAG), and BART Impact Program projects (most notably the Land Use and Urban Development Project, the Transportation System and Travel Behavior Project and the Environment Project). Much of the regional information came from reports prepared by the research department of Security Pacific Bank. Exact data sources are cited throughout the text.

Report Organization

A summary of the material in the body of the report is located at the front of the document. The remaining chapters are organized as follows:

II. Bay Area Setting, with sections on the region's geography and climate, patterns of urbanization, population and employment, and transportation planning and facilities.

III. BART Chronology, a short chapter highlighting BART's history from before 1957 through the present, including target dates for future system improvements.

IV. Design and Construction, with sections on the basic objectives and standards for design of BART, the management and accomplishment of system design and construction, land acquisition and dwelling unit displacement, and the system's capital costs and funding sources.

V. Physical Facilities, describing the trackway, stations and service facilities which make up the BART system and discussing the characteristics of its facilities for handicapped patrons and travel modes for gaining access to BART stations.

VI. BART Operational Features, including descriptions of the train vehicle, the automatic train control system, and the system's service characteristics. BART fares, patronage, and characteristics of the trips made on BART and the persons making them are also discussed, as are the system's public safety, energy use, operating costs and revenues, and organization and management.

VII. Adjacent Land Use and Population, describing the land use characteristics of the areas near BART facilities, the adjacent transportation facilities followed by BART lines, and the characteristics of residents in the primary BART service area and in the areas immediately adjacent to BART facilities.

II. BAY AREA SETTING

Introduction

The regional setting into which a transit system is introduced influences the form and character of the system and largely determines its uses and the level of its patronage. In this chapter, the Bay Area's geography and climate, the patterns of its urbanization and the characteristics of its population and its economic activities are discussed. Descriptions of the area's transportation patterns and the regional planning agencies and local providers of transit service (other than BART) are presented as further context for viewing the BART system.

Geography and Climate[1]

The San Francisco Bay Area consists of the nine counties around the connecting San Francisco, San Pablo and Suisun Bays (Figure II-1). Marin, Sonoma, Napa and Solano Counties occupy the northern part of the region; Contra Costa and Alameda are the East Bay Counties; Santa Clara County extends south and east from the southern tip of San Francisco Bay; and San Mateo County occupies most of the peninsula separating the San Francisco Bay from the ocean, with the City and County of San Francisco at the northern tip of the peninsula. These counties encompass 7,500 square miles, of which 7,000 square miles are land.

The Bay is an outstanding harbor and the region's most notable geographic feature. It covers 450 square miles, ranging from 3 to 12 miles in width and up to 48 miles in length. The Bay Plain, a band of flatlands and tidal marshlands (much of which has been filled), rings the Bay and separates it from the chain of coastal mountains which virtually surrounds it.

The Bay Area has a semi-arid climate which is typically mild and temperate (classified as cool Mediterranean). The topographic diversity of the region, however, causes considerable climatic variation within the area. Near the ocean and the Bay, breezes from the water contribute to relatively even year-round temperatures, while inland areas experience greater annual variation in temperature. San Francisco's average temperature ranges from about 50 to 60 degrees, with its warmest weather in the late spring and early autumn. Summer temperatures are typically higher and winter temperatures lower in interior valleys such as the Napa, Sonoma and Livermore Valleys. Throughout the region, summers are characteristically dry, with the rainy season extending from November through March. The mean annual rainfall ranges from 37 inches in San Rafael (Marin County) to 13 inches in San Jose (Santa Clara County), with further wide variation in amounts of rainfall from valley to hill.

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[1] Security Pacific National Bank, San Francisco Bay Area Report. San Francisco, April 1971.

FIGURE II-1
SAN FRANCISCO BAY AREA

Patterns of Urbanization[1]

Within the nine-county Bay Area there are 1,360 square miles of useable land.[2] By 1975, 51 percent (698 square miles) of this land was developed for urban uses. Within the three counties where BART is located there is considerable variation in the proportions of land developed: In 1975, 97 percent (38 square miles) of San Francisco County, 71 percent (141 square miles) of Alameda County and 47 percent (106 square miles) of Contra Costa County was developed into urban uses. Table II-1 shows relative density of development in these areas as reflected by persons and housing units per useable acre.

TABLE II-1
BAY AREA URBAN DEVELOPMENT, POPULATION AND HOUSING DENSITY (1975)

Area	Percent Developed Into Urban Uses	Persons/ Usable Acre	Housing Units/ Usable Acre
Alameda County	71%	8.6	3.1
Contra Costa County	47%	4.1	1.4
San Francisco County	97%	26.9	11.9
Bay Area (Nine-County)	51%	5.5	2.0

Source: ABAG, **Series 3 Projections**, 1977.

The Area's topography is reflected in its patterns of urbanization; extensive development has taken place where site preparation is not unreasonably expensive and in areas easily accessible to the Bay. Thus the Bay Plain has been the natural site for development. Early concentration of development occurred in San Francisco, northern Alameda County, northern and western Contra Costa County, and along the bayshore of San Mateo County. More recent (postwar) development has been centered in the southern flatlands and valleys of Alameda and Santa Clara Counties. The hills surrounding the Bay have been sites for urban and suburban residential development, although the cost of developing the hillsides has encouraged the preservation of wooded open spaces in the area.

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[1] Association of Bay Area Governments (ABAG), Provisional Series 3 Projections: Population, Housing, Employment and Land Uses - San Francisco Bay Region. Berkeley, March 1977.

[2] Useable area excludes inland bodies of water, land designated as permanent open space, and most of the controlled development open space in the ABAG Regional Plan 1970-1990.

The Bay Plain consists of 80 miles of bayshore with nearly continuous urban development. While it constitutes about 10 percent of the region's land area, it is the location of 70 percent of the Bay Area's population and 80 percent of its economic development. The main centers of urban activity, San Francisco, Oakland and San Jose, lie within the Bay Plain. A number of urban subcenters and strips of industrial facilities account for most of the remaining Bay Plain development.

Population[1]

Between 1960 and 1970, the Bay Area population increased 27 percent, from 3,639,000 to 4,628,200. The 1975 population is estimated to be 4,829,200, approximately a 5 percent increase over the 1970 population (Table II-2). Population is concentrated in two of the nine counties; Santa Clara County (population 1,169,700) and Alameda County (population 1,089,900) house nearly half of the region's population. About 49 percent of the Bay Area population lives in the three counties where BART is located (Figure II-2).

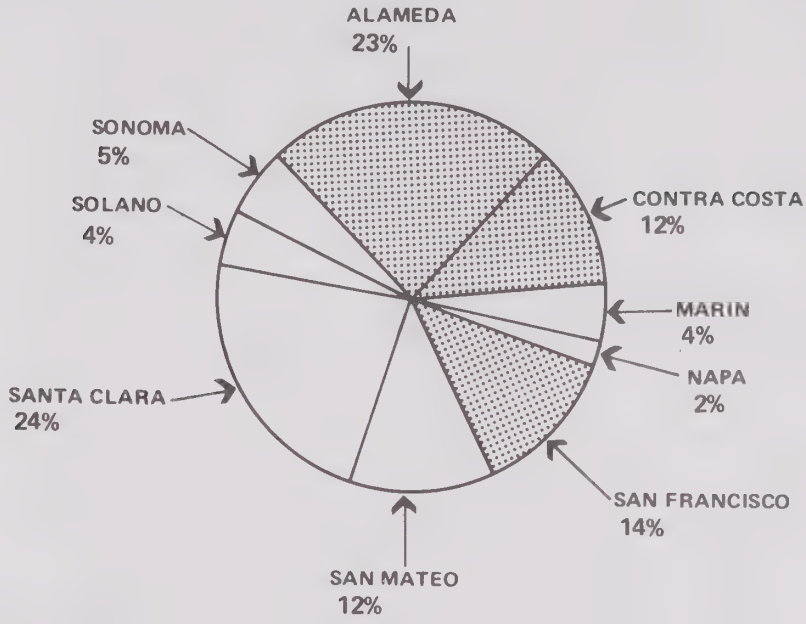
TABLE II-2
SAN FRANCISCO BAY AREA POPULATION BY COUNTY, 1950-1975

County	Census April 1, 1950	Census April 1, 1960	Census April 1, 1970	Estimate 1975
Alameda	740,315	908,209	1,073,184	1,089,900
Contra Costa	298,984	409,030	558,389	582,800
Marin	85,619	146,820	206,038	216,100
Napa	46,603	65,890	79,140	90,000
San Francisco	775,357	740,316	715,674	672,600
San Mateo	235,659	444,387	556,234	576,400
Santa Clara	290,547	642,315	1,064,714	1,169,700
Solano	104,833	134,597	169,941	186,300
Sonoma	103,405	147,375	204,885	245,400
NINE-COUNTY TOTAL	2,681,322	3,638,939	4,628,199	4,829,200

Source: Security Pacific Bank Research Department with data from the U. S. Department of Commerce and the California Department of Finance. Estimate for 1975 from ABAG, **Series 3 Projections**, 1977.

[1] Security Pacific Bank, A Special Report on the Economy of the San Francisco Bay Area. San Francisco, September 1975.

FIGURE II-2
PERCENT DISTRIBUTION OF POPULATION
San Francisco Bay Area, by County - 1975



Source: ABAG Series 3 Projectives, 1977

Since 1950, the major growth has occurred in the southern portion of the Bay Area, while San Francisco and Oakland have declined in population. Ten of the region's 15 cities which doubled in population between 1960 and 1970 are in Santa Clara County and southern Alameda County. Projections to 1990 indicate a 10-15 percent increase over the 1975 Bay Area population (Table II-3), with patterns of population growth and distribution similar to those of the decade 1960-1970.

TABLE II-3
POPULATION PROJECTION, 1990
(THOUSANDS OF PERSONS)

Area	1975 (Base Year)	1990 (Levels)	Percent of Change
Alameda County	1,090	1,163 - 1,180	+ 7 - 8%
Contra Costa County	583	691 - 774	+ 19 - 33%
San Francisco County	673	642 - 645	– 5 - 6%
Bay Area (Nine-County)	4,829	5,284 - 5,622	+ 9 - 16%

Source: ABAG, Series 3 Projections, 1977.

As shown in Table II-4, populations of cities traversed by BART have a mixed pattern: The central cities of San Francisco and Oakland lost population between 1950 and 1975; cities along the Richmond line generally declined or gained very little in population; and along the Concord line and southern portions of the Fremont line, cities increased in population.

TABLE II-4
POPULATION TRENDS OF CITIES TRAVERSED BY BART, 1950-1975

City	1950	1960	1970	1975	Percent of Change 1960-1970	Percent of Change 1970-1975
Albany	17,590	14,804	14,674	14,400	– 1%	– 2%
Berkeley	113,805	111,268	116,716	108,500	+ 5%	– 7%
Concord[a]	6,953	36,000	85,164	91,900	+ 137%	+ 8%
Daly City[a]	15,191	44,791	66,922	72,500	+ 49%	+ 8%
El Cerrito	18,011	25,437	25,190	23,700	– 1%	– 6%
Fremont	–	43,790	100,869	116,200	+ 130%	+ 15%
Hayward[a]	14,272	72,700	93,058	94,200	+ 28%	+ 1%
Lafayette	–	–	20,484	20,300	–	+ 1%
Oakland[a]	384,575	367,548	361,561	336,600	– 2%	– 7%
Richmond[a]	99,545	71,854	79,043	73,600	+ 10%	– 7%
San Francisco	775,357	740,316	715,674	671,100	– 3%	– 6%
San Leandro[a]	27,542	65,962	68,698	68,000	+ 4%	– 1%
Union City[a]	–	6,618	14,724	27,800	+ 122%	+ 89%
Walnut Creek[a]	2,420	9,903	39,844	47,250	+ 302%	+ 19%

a Cities which annexed additional territory between 1960 and 1970.

Source: U. S. Department of Commerce, Bureau of the Census, **1970 Census of the Population, Number of Inhabitants—California,** Washington, D. C., September 1971. Estimate for 1975 from California Department of Finance and Security Pacific Bank.

Regional Population Characteristics[1]

In 1970, median household income for the nine-county region was $11,500. Areas of low incomes were largely concentrated in central core cities and minority communities. The more extensive high income areas were found in less developed parts of the region, typically in areas of attractive natural surroundings.

Of the three BART counties, only Contra Costa showed a median income above the regional average, while Alameda and San Francisco Counties showed median incomes below average. At the community level, the highest median incomes in BART counties occurred in south central Contra Costa County (Orinda, Moraga, Lafayette and Alamo); in Alameda County's Berkeley hills area, Piedmont, and the Fremont hills; and in San Francisco's Seacliff (outer Richmond) and Pacific Heights districts. Lowest median incomes were in central and southeast San Francisco (Bayshore and South-of-Market districts); in northwestern Contra Costa County (Richmond and Pittsburg); in western Alameda County (south Berkeley and East and West Oakland). Low median incomes were related to rates of unemployment above the regional average in the BART counties of Alameda and San Francisco. Among cities traversed by BART, unemployment rates were highest in the cities of Berkeley, Oakland and Richmond.

Within the Bay Area, the three most significant minorities are the Spanish-heritage, Black and Asian populations. The 1970 Census reported that of the nine-county population, 13 percent (589,963 persons) were of Spanish heritage, 8 percent (367,472 persons) were Black, and 5 percent (211,782 persons) were Asian. Among the counties where BART is located, minority populations are most highly concentrated in San Francisco and Alameda Counties. Persons of Spanish heritage were concentrated in southern Alameda County, in the Fillmore and Mission districts of San Francisco, in Daly City, and in parts of Oakland. Major concentrations of Black population were found in San Francisco, Richmond, Berkeley and Oakland. The census showed that about one-half of the region's Asian population was located in San Francisco, with another 20 percent in Alameda County.

The regional median age in 1970 was 27.6. Of the nine counties, San Francisco had the highest median age of 33.4 years. The young and the elderly constitute significant social minorities in the region. Persons under 16 constituted 28.6 percent of the region's population in 1970. The proportion of young persons was lowest in San Francisco (19.9 percent); significant numbers of young people were concentrated in areas outside the central cities in parts of Alameda and Contra Costa Counties. About 9 percent of the region's population (410,000 persons) in the 1970 Census were age 65 and older. The percentage of elderly was highest in San Francisco (14 percent). About half of the region's total elderly population was found in San Francisco and Alameda Counties.

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[1] Metropolitan Transportation Commission, Draft Environmental Impact Report: MTC Regional Transportation Plan. Berkeley, March 1974.

The nine-county region had a total of 1.6 million households in 1970, with most households concentrated in Alameda, Santa Clara and San Francisco Counties. A regional median of 2.14 persons occupied each unit, and of the total units, 64 percent were single-family units. San Francisco had only a third of its housing in single-family units, while in the remaining counties single-family units represented from two-thirds to over nine-tenths of the housing units.

Employment

The Bay Area's total employment in 1975 was estimated to be a little over 2 million.[1] The three BART counties account for 53 percent of the region's employment (Table II-5).

TABLE II-5
BAY AREA EMPLOYMENT AT PLACE OF WORK, 1975
(THOUSANDS OF PERSONS)

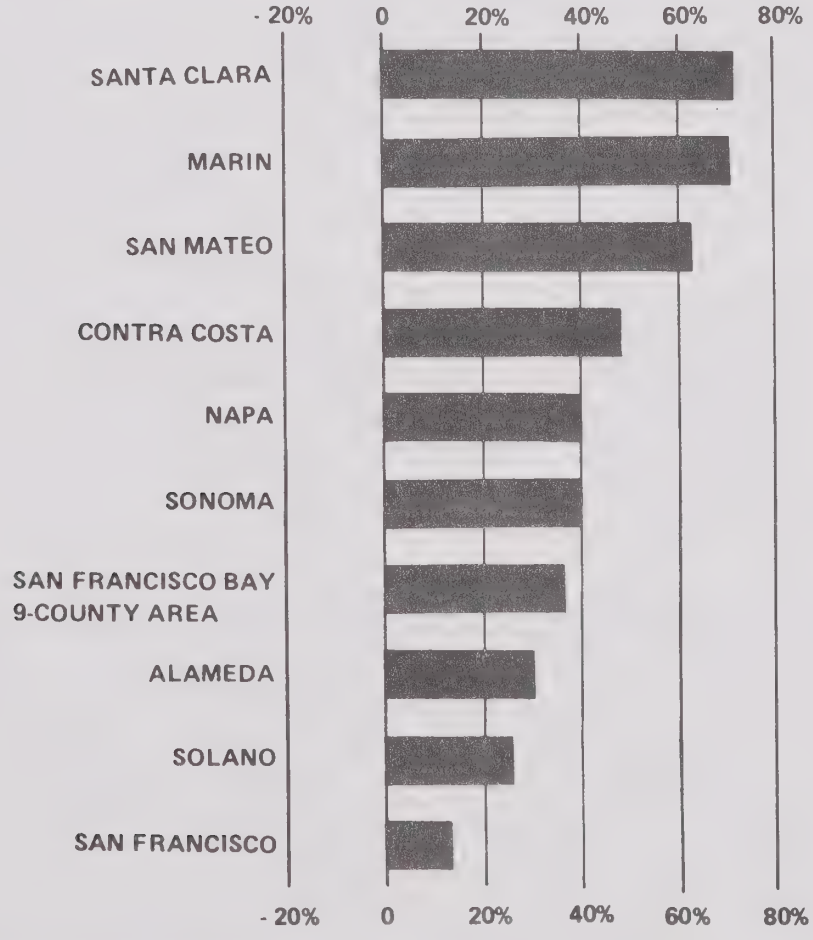
County	Total Employment	Percent of Region
Alameda	434.3	21%
Contra Costa	160.1	8%
Marin	55.7	3%
Napa	28.6	1%
San Francisco	495.4	24%
San Mateo	225.1	11%
Santa Clara	517.8	25%
Solano	52.3	3%
Sonoma	77.3	4%
REGIONAL TOTAL	2,046.4	100%

Source: ABAG, **Series 3 Projections**, 1977.

[1] ABAG, Series 3 Projections, 1977. Total employment includes all employed residents at their places of work.

Of the nine counties, Santa Clara County experienced the greatest numerical and percentage growth in employment during the period 1960-1970, paralleling its growth in population. Contra Costa is the only BART county with an employment rate for that period higher than the nine-county average (Figure II-3). In 1960, the three BART counties provided 64 percent of the region's total employment, while in 1975 they accounted for 53 percent; this decline is indicative more of the strong growth in the southern area than of a lack of growth in the three counties served by BART.

FIGURE II-3
PERCENT CHANGE IN TOTAL EMPLOYMENT
SAN FRANCISCO BAY AREA, BY COUNTY, 1960-1970



Source: Economic Research Department, Security Pacific Bank with data from the California Department of Human Resources.

Employment projections to 1990 indicate about a 15-25 percent increase over 1975 employment. It is projected that in the region as a whole and in Alameda and Contra Costa Counties the employment growth rate will slow down in comparison to the rate between 1960 and 1970. However, in San Francisco it is projected that the rate will be somewhat greater than it has been in the past (Table II-6).

TABLE II-6
EMPLOYMENT PROJECTIONS, 1990
(THOUSANDS OF PERSONS)

Area	1975 (Base Year)	1990 (Levels)	Percent of Change
Alameda County	434	480 - 507	11 - 17%
Contra Costa County	160	189 - 213	18 - 33%
San Francisco County	495	568 - 595	15 - 20%
Bay Area (Nine-County)	2,047	2,041 - 2,581	17 - 26%

Source: ABAG, **Series 3 Projections**, 1977.

Eighty percent of the region's workers in 1970 were employed in four of eight basic industry groups: Wholesale and retail trade, services, government and manufacturing (Table II-6). Services and government were the industries leading in 1960-1970 employment growth numbers for the Bay Area and for each of the three BART counties. The leading industry changed during that period in each of the BART counties (Table II-7).

TABLE II-7
LEADING INDUSTRIES IN SAN FRANCISCO BAY AREA, 1960 AND 1970

County	1960 Leading Industry	1970 Leading Industry
Alameda	Trade	Government
Contra Costa	Manufacturing	Trade
Marin	Trade	Services
Napa	Government	
San Francisco	Trade	Services
San Mateo	Trade	
Santa Clara	Manufacturing	
Solano	Government	
Sonoma	Trade	
Nine-County Region	Trade	Services

Source: Economic Research Division, Security Pacific Bank, with data from the California Department of Human Resources Development.

Regional and Transportation Planning

Political jurisdictions within the Bay Area consist of the nine-county governments, 93 city governments, and numerous special districts. Regional planning in the nine-county San Francisco Bay Area is conducted by the Association of Bay Area Governments (ABAG), Bay Area Air Pollution Control District (BAAPCD), Bay Area Conservation and Development Commission (BCDC), California Department of Transportation (Caltrans), Metropolitan Transportation Commission (MTC) and the North Central and Central Coastal Commissions. The main regional land use planning agency is the Association of Bay Area Governments (ABAG); regional transportation planning is the concern of the Metropolitan Transportation Commission (MTC). ABAG and MTC agree to a sharing of resources for regional land use planning as an essential prerequisite to transportation planning, and MTC agrees to recognize the ABAG Comprehensive Regional Plan as the basis for the preparation of all transportation plans. MTC's regional transportation plan is recognized as the transportation element of the Comprehensive Plan. Further descriptions of these agencies and their functions are presented below.

Association of Bay Area Governments

ABAG was formed in 1961 to function as the regional planning agency for the nine-county Bay Area. Membership in ABAG is voluntary. As of 1977, seven of the nine counties in the Bay Area were participating members, as were 87 of the region's 93 cities, representing about 97 percent of the region's population. The Federal A-95 review power is lodged with ABAG, but MTC reviews transportation plans, subject to ABAG concurrence.

ABAG policy is determined by a general assembly, which convenes twice yearly. Delegates to the general assembly are elected officials from member cities and counties. Each city and county has one vote, and a majority of both city and county votes is required for action. A 35-member executive board of locally elected officials, with representation based on population, meets monthly to make operating decisions, appoint committees, authorize expenditures and recommend major policy decisions to the general assembly.

Metropolitan Transportation Commission

In 1970, the California State Legislature created the Metropolitan Transportation Commission. MTC has three major assignments:

- Prepare, periodically update and implement a Regional Transportation Plan for the nine-county region.
- Act as the central review agency for all Bay Area agencies seeking transportation funding from the State or Federal government.

- Monitor the effectiveness and performance of the Bay Area's transit operations.

The Bay Area's most populous counties -- Alameda, Contra Costa, San Francisco, San Mateo and Santa Clara -- have two voting commissioners each, appointed by county supervisors and mayors. The counties of Marin, Solano, Napa and Sonoma each appoint one voting member. Commissioners representing the Association of Bay Area Governments (ABAG) and the Bay Conservation and Development Commission (BCDC) each have one vote, and non-voting commissioners represent the California Department of Transportation, the U.S. Department of Transportation, and the U.S. Department of Housing and Urban Development. To encourage citizen participation, MTC conducts activities such as public hearings, workshops and informal meetings.

Travel Characteristics and Transportation Facilities

It is estimated[1] that approximately 5 million vehicle trips are made on an average weekday in the BART service area (Alameda, Contra Costa, San Francisco and northern San Mateo Counties). Of this total, about 30 percent are for work purposes, 7 percent for business, 11 percent for school, 20 percent for shopping and the remainder (32 percent) are for miscellaneous purposes, including recreation, visits to friends and personal business trips.

Findings from various sources regarding vehicular travel mode mix indicate a high preference for automobile travel. From the BART Impact Program's 1975 telephone survey (1,000 respondents) taken in the BART service area, the overall mode mix was found to be 87 percent automobile and 13 percent transit. This preference for the automobile is further reflected in Figure II-4, which shows that auto ownership in the BART area has been increasing faster than the population, that total road mileage continues to be expanded, and that the number of persons per auto continues to decline.

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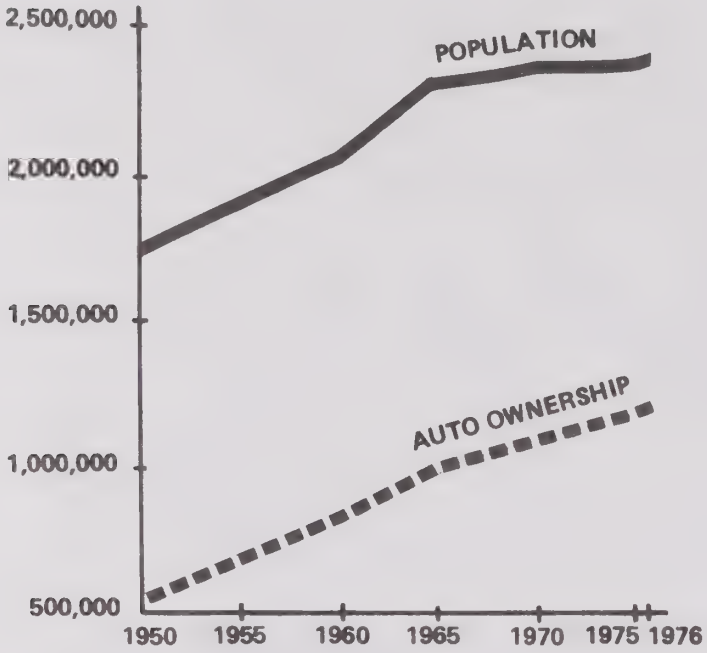
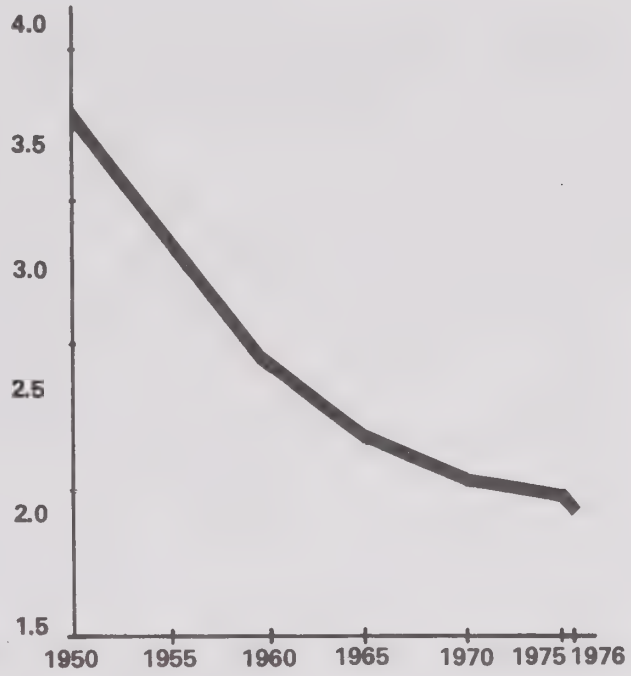
[1] For additional information and analysis, see: Peat, Marwick, Mitchell & Co., Travel in the BART Service Area, Document No. DOT-BIP-WP 35-3-77, Berkeley: Metropolitan Transportation Commission, September 1977.

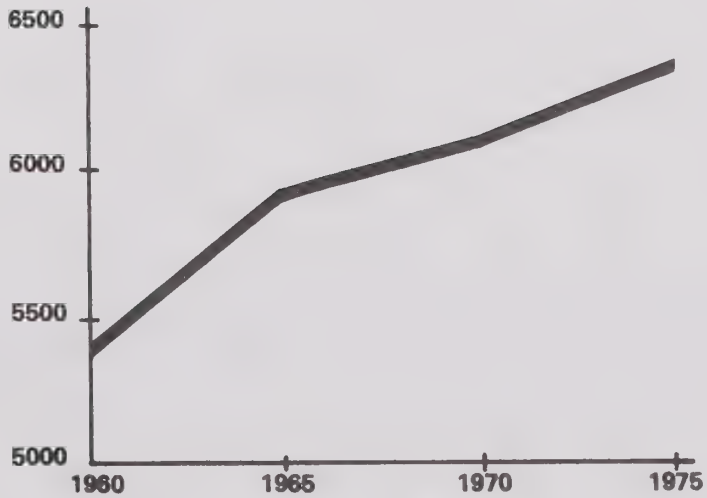
FIGURE II-4
GROWTH OF AUTOMOBILE UTILIZATION IN THE BART SERVICE AREA



POPULATION COMPARED
TO AUTO OWNERSHIP



PERSONS/AUTO



TOTAL ROAD MILEAGE—1960-1975

Including its streets, county roads and highways, the Bay Area as of 1974 had 17,600 miles of roadway (Table II-8).

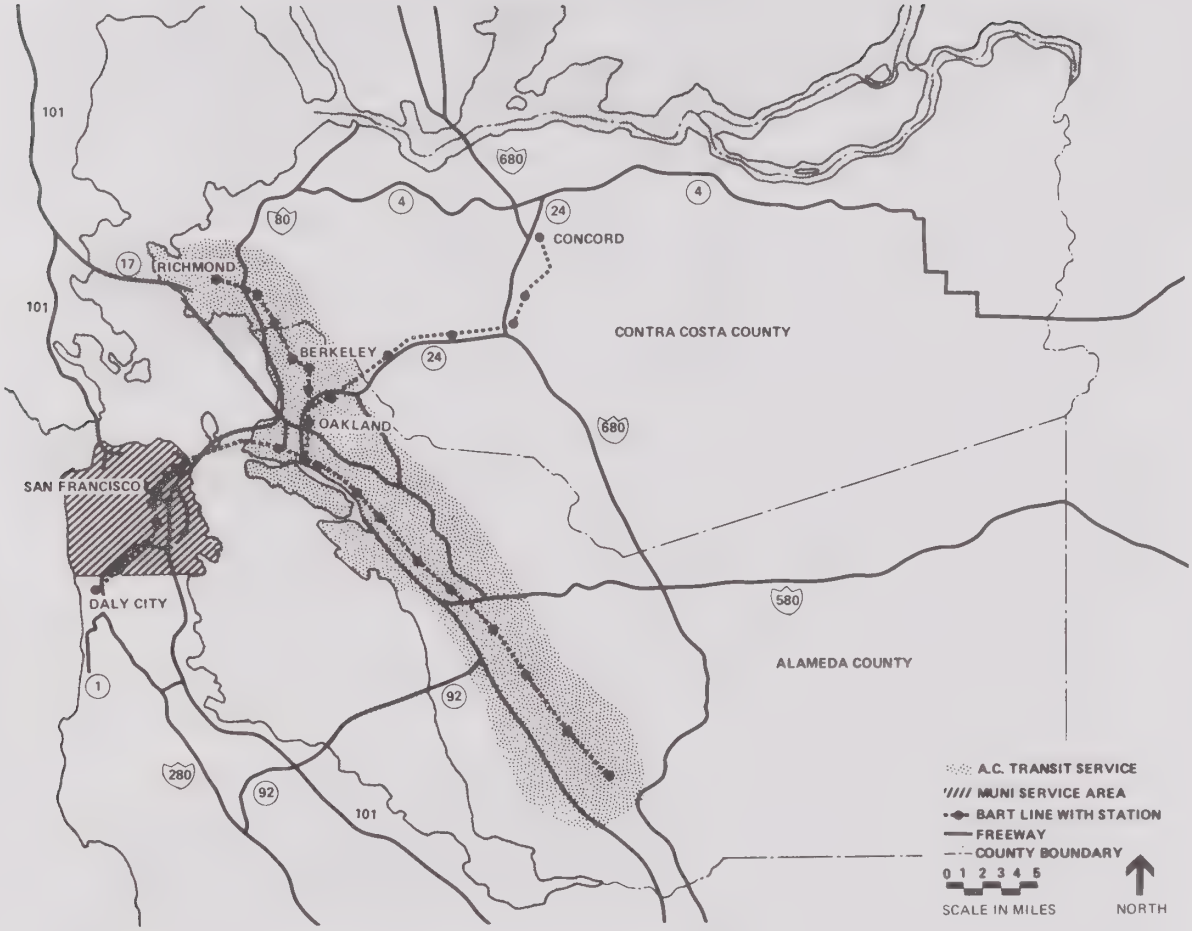
TABLE II-8
ROAD MILEAGE BY COUNTY, 1974

County	State/ National Highways	City Streets	County Roads	Total
Alameda	210	2,250	545	3,005
Contra Costa	138	1,292	1,022	2,452
Marin	311	513	421	1,245
Napa	128	201	480	809
San Francisco	60	844	–	904
San Mateo	215	1,335	365	1,915
Santa Clara	249	2,795	837	3,881
Solano	161	476	650	1,287
Sonoma	255	436	1,440	2,131
NINE-COUNTY BAY AREA TOTAL	1,727	10,142	5,760	17,629

Source: **California Statistical Abstract**, 1975.

As shown in Figure II-5, all BART lines generally parallel major freeways. The Daly City line parallels I-280 and Route 101; the Richmond line, I-80; the Concord line, Route 24; and the Fremont line, Route 17 (and to a lesser extent I-580). Oakland and the other East Bay cities are linked to the San Francisco Peninsula and Marin County by three major highway toll bridges: the San Francisco-Oakland Bay Bridge (generally known as the Bay Bridge), the San Mateo-Hayward Bridge, and the Richmond-San Rafael Bridge. Other major highway links are the Golden Gate Bridge, linking Marin County to San Francisco, and the Caldecott Tunnel on Route 24 through the Berkeley Hills, linking central Contra Costa County to Berkeley and Oakland.

FIGURE II-5
BART AND OTHER TRANSPORTATION FACILITIES



The most heavily traveled of these highway links is the San Francisco-Oakland Bay Bridge, which parallels the BART Transbay Tube and connects the freeways of the San Francisco peninsula and the employment centers of San Francisco directly to Oakland and the freeways leading to the industrial and residential areas of the East Bay. The Bay Bridge carries about 95,000 vehicles per day in each direction.

Public Transit Service

Several transit operators in addition to BART provide service within the Bay Area. The most important of these are described below:

- San Francisco Municipal Railway (MUNI).[1] MUNI is a multi-modal operation in the City and County of San Francisco (see Figure II-5). Its fleet is made up of streetcars, cable cars, trolley buses and motor buses. In late 1976 average ridership on all services of MUNI was about 345,000 one-way trips.

- Alameda-Contra Costa Transit District (AC). As the main bus operator in the East Bay, AC Transit provides scheduled bus service in the cities west of the Berkeley and San Leandro Hills from Richmond in the north to Fremont in the south, an area of approximately 200 square miles (Figure II-5) with a population of more than one million. In addition to local and express bus service in the East Bay, AC Transit operates extensive bus routes across the San Francisco-Oakland Bay Bridge to the Transbay Bus Terminal on the edge of downtown San Francisco. Under contract to the BART District, AC also provides "BART Express Bus" service to and from portions of the BART District beyond the immediate service area of BART stations. In May 1976, total AC Transit ridership amounted to about 210,000 trips per day.

- Southern Pacific Railroad (SP). Southern Pacific Railroad furnishes commuter rail service between San Francisco and cities on the San Francisco peninsula in San Mateo and Santa Clara Counties. Weekday ridership to or from San Francisco averages about 16,000 trips.

- Greyhound Lines. Greyhound Lines commuter buses serve the area east of the Berkeley Hills in central Contra Costa County.

  Greyhound commuter service consists mainly of express service between terminals in Orinda, Lafayette, Walnut Creek, Concord, and downtown San Francisco. Transbay BART service greatly reduced Greyhound ridership on these services. In May 1975, average ridership was 2,900 trips per day; by October 1976, it had dropped to 1,700 trips. Schedules have been cut back correspondingly.

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[1] In downtown San Francisco BART stations there is a separate platform level for a subsurface light rail transit line, MUNI Metro, which is scheduled to begin service in 1979. The line will replace the surface streetcars presently running on Market Street. Like the present system, it will branch off in five directions to serve outlying neighborhoods, mostly at street level.

- San Mateo Transit District (SamTrans). Bus service in San Mateo County to Daly City BART Station, and to downtown San Francisco.

Other major transit operations (but not in the same areas as served by BART) include Golden Gate Bridge, Highway and Transportation District and the Santa Clara Transit District. The combined patronage for all of these transit services (not including BART) is approximately 600,000 transit trips per weekday.

III. BART CHRONOLOGY[1]

Pre-1957 History

The history of BART began in 1947 when a joint Army- Navy review board concluded that another connecting link between San Francisco and Oakland would be needed to prevent intolerable congestion on the Bay Bridge. In 1951 the State Legislature created the San Francisco Bay Area Rapid Transit Commission, whose charge was to study the Bay Area's long-range transportation needs. The Commission's final report in 1957 contained a recommendation that a five-county rapid transit district be formed whose mandate would be to build and operate a high-speed rail network linking major commercial centers with suburban subcenters. So began what ultimately resulted in the present BART system. The highlights of BART's history from 1957 to the present are outlined below.[2]

Planning and Construction (1957-1972)

June 1957	California Legislature approved creation of five-county BART District (including Alameda, Contra Costa, Marin, San Francisco and San Mateo Counties).
November 1957	Five-county BART District officially activated.
May 1959	Consultants to the BART District (Parsons Brinckerhoff-Tudor-Bechtel) retained for system design engineering and construction management.
April 1962	San Mateo County withdrew from the District.
May 1962	Marin County withdrew from the District.
May 1962	Three-county rapid transit plan (Composite Report) adopted by BART board.
November 1962	$792 million General Obligation bond issue approved by voters.

[1] For additional information and analysis see: McDonald & Smart, Inc., A History of Key Decisions in the Development of Bay Area Rapid Transit, Document No. FR 3-14-75, Berkeley: Metropolitan Transportation Commission, September 1975.

[2] BART Office of Public Information, Chronology. November 1976.

July 1963	Full-scale design and engineering began.
June 1964	Official construction began.
July 1969	Contract awarded to Rohr Corporation for design and manufacture of transit vehicle.
July 1971	Last rail set in place to complete linking of all system mainline trackage.
June 1972	Pre-revenue train testing began.

Operations (1972-1977)

September 1972	Fremont line opened (28 miles and 12 stations).
January 1973	Richmond line opened (11 miles and 6 stations).
May 1973	Concord line opened (17 miles and 7 stations).
November 1973	Daly City line to San Francisco's central business district opened (7 1/2 miles and 8 stations).
September 1974	Transbay Tube opened, revenue service between San Francisco and Oakland.
January 1976	Permanent night service started (8:00 p.m. to midnight).
May 1976	Embarcadero station in downtown San Francisco opened (last of 34 stations).
November 1977	Permanent Saturday service started.

Future (1978)

March 1978	Start of direct service between Richmond and San Francisco.
June 1978	Start of permanent Sunday service.

IV. DESIGN AND CONSTRUCTION

Introduction

This section reports selected data on the design of BART stations and line segments and on construction of the system. It begins with the overall standards and objectives set forth initially to guide development of BART, followed by a brief description of the process and participants in the system's engineering, design and construction. Data on the sequence of events during construction and the time required for construction are presented, as well as a discussion of system land acquisition detailing both land take and dwelling unit displacement. The final part of this section describes capital costs of construction and equipment and indicates sources of the funds.

Basic Objectives and Standards

Some of the more salient standards established for the Bay Area Rapid Transit system are the following:[1]

- The regional rapid transit equipment must be capable of speeds of at least 70 miles per hour between stations, generally averaging speeds of approximately 50 miles per hour, with minimum average speeds of about 45 miles per hour. This requires high rates of vehicle acceleration and deceleration and high balancing speeds, which in turn demands easy track alignment, minimum grades, and complete separation of the rapid transit facility from all conflicting traffic.

- Service during periods of peak travel should be governed by demand, with headways as short as 90 seconds to provide a capacity of at least 30,000 seated passengers per hour in each direction on each route. Off-peak service, except late at night, should be as frequent as every 15 minutes.

- The system must be safe and dependable, and train control must be reliable. Automatic train control by electronic computer is an essential part of the system.

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[1] Parsons Brinckerhoff-Tudor-Bechtel, The Composite Report: Bay Area Rapid Transit. San Francisco, May 1962.

- The rapid transit car must be comfortable, with smooth riding qualities, internal temperature control, adequate ventilation, cooling and heating, sealed windows, freedom from fumes, a low internal and external noise level, and a pleasing interior and exterior appearance. The system structure must be aesthetically acceptable.

- The regional system must penetrate the major centers of business and commerce close to the ultimate destinations of travelers to those centers. The location of individual routes and stations is dictated basically by the requirements of the communities and the people to be served and by the limits imposed by topography and existing development.

- The adopted method of rapid transit must involve the minimum capital and operating expenditures consistent with these specified standards.

- The proposed three-county regional rapid transit system is intended as the foundation for a larger regional rapid transit system for the entire Bay Area. Future extensions have been anticipated in the development of routes.

As set forth in the Composite Report, benefits and costs expected to result from the initial Bay Area Rapid Transit plan were as follows:

- Utilizing only a fraction of the space required for a modern freeway, rapid transit would provide for more passenger capacity than automobiles on freeways, and at much less cost.

- The system is expected to benefit the Bay Area by permitting increased concentration and specialization of business, industry and other economic activity. The rapid transit system would help to reduce disorganized urban sprawl; to improve Bay Area living and working conditions; and to preserve and increase property values in the central cities, regional subcenters and outlying areas.

- Measurable benefits to the area would result from savings in travel times, reduction in accident costs, savings in automobile costs, and savings in the cost of motor freight shipment. Other benefits would include savings in the costs of constructing and maintaining an otherwise larger network of bridges and freeways, the increased potential for Bay Area economic growth and the savings resulting from more efficient and orderly patterns of development and land use throughout the area.

- Fixed elements of the system such as right-of-way, track construction, stations, and power and control systems -- but not including the Transbay Tube -- are estimated to cost $790,493,000, including allowances for inflation and pre-operating expenses. These costs are proposed to be financed by District general obligation bonds in a recommended amount of $792,000,000 to be sold between 1963 and mid-1970.

- Rolling equipment for the system is estimated to cost $71,200,000 through the year 1978, when a total of 450 modern rapid transit cars will be required. The District's financing plan provides for rolling equipment requirements through 1971, to be financed from issuance of revenue bonds secured by a pledge of gross system revenues. Subsequent purchases of equipment are to be made directly from surplus net revenues from transit operations.

- The Transbay Tube and its approaches are estimated to cost $132,720,000 and are to be financed primarily by revenue bonds of the California Toll Bridge Authority.

- When the system is complete, it will be self-supporting except for payment of general obligation bonds sold to finance fixed elements of the system.

Management of BART Design and Construction[1]

The BART Board of Directors reached an early decision that planning, design and management of construction would be performed by consultants under contract to the District, rather than the District attempting to assemble a staff of its own. The Board selected a three-firm joint venture consisting of Parsons, Brinckerhoff, Quade and Douglas; Tudor Engineering; and Bechtel Corporation (PBTB). In addition to broad general capabilities, each of the member firms had certain areas of expertise. For instance, Parsons had prime responsibility for the Transbay Tube and cut-and-cover portions of the system, Tudor for design of the aerial structures, and Bechtel for tunnel design and construction management.

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[1] David G. Hammond, "Management of Large Projects." Paper delivered at ASCE Conference, San Francisco, October 1977.

While PBTB was an independent contractor, their role was to act as BART staff in performing all of the engineering design and related functions necessary to prepare construction contract documents, in supervising construction and eventually in placing the system into operation. The formal chain of command between PBTB and the District had the Project Director for PBTB reporting to the BART General Manager. The General Manager was guided by policies and directives of the BART Board of Directors. A later decision (although still early in the project) was made not to place the sole responsibility and authority with the joint venture, but to establish within the BART organization a small technical group that could provide direction to PBTB and technical advice and assistance to both the BART top management and to PBTB.

Design Guidelines and Participants

General criteria for station design were set forth in the Manual of Architectural Standards.[1] Each station was to be detailed to fit its specific site, purpose, and flow of patrons. The Manual's Foreword established the architect's role as that of developing a station which "meets standards and requirements established for all stations, and at the same time is a separate unit, with its own individuality and architectural character." Within the limits set by system-wide engineering criteria, the station designers were encouraged to seek solutions which would be innovative and attractive. The criteria in the Manual stress the importance of providing for the patron's comfort and convenience by urging architects to design stations which are inviting, well-lighted, clean and, especially important, in which passengers can move about with a minimum of crowding and a maximum of convenience.

The architectural manual was a general architectural program for the stations. Accordingly, it contained only enough information on technical design aspects (such as platform dimensions, mechanical and electrical systems, communication systems, train control systems and heating/ventilating systems) to enable architects to make necessary space allocations. Some of the requirements, however (such as the 700-foot-long train platform; the 280-foot canopy covering the above-ground platform; and the program for placement of ticketing machines, fare gates, station agent booths and vertical circulation elements), gave strong definition to the resulting station form and design.

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[1] Wurster, Bernardi & Emmons, Manual of Architectural Standards, Parsons Brinckerhoff-Tudor-Bechtel. San Francisco, June 1965.

In addition to the architectural and engineering[1] manuals, the architects were guided by the following plans:

- Plan of External Traffic provided data on station access for development of traffic flow patterns around stations, including handling of pedestrians, buses and kiss-and-ride patrons.

- Site Development Plan established location and boundaries of station sites, as well as parking layout and landscaped areas.

- Station Definitive Plan established location of the platform and station core (the portion of the station containing the fare collection equipment, station agent's booth, concessions, toilets, waiting areas and service areas).

Design responsibility for the BART stations was shared by two groups of architects. An early and continuing participant was the consulting architect and his advisors. They were responsible to the three-firm joint venture. Donn Emmons served as the first consulting architect on a part-time basis from 1963 through 1966. During that time the architectural manual was developed; the decision to use different architects for different stations was made, and the architects selected; early conceptual station designs (for station budgeting) were formulated; and all of BART's aerial structures were designed. Tallie Maule replaced Emmons as consulting architect and subsequently became the joint venture's permanent chief architect. It was his responsibility to coordinate and work with the architectural firms selected to design BART stations. A total of 15 architectural firms and 8 landscape architectural firms designed the BART facilities, along with several graphic designers, industrial designers and artists. Table IV-1 lists the architect and landscape architect for each BART station.

[1] Parsons Brinckerhoff-Tudor-Bechtel, Civil and Structural Design Criteria, Volumes I and II. San Francisco, 1968.

TABLE IV-1
BART STATION ARCHITECTS

Stations	Project Architects	Landscape Architects
Embarcadero	Tallie B. Maule/Hertzka & Knowles Associates	Sasaki-Walker Associates
Montgomery Street	Skidmore, Owings & Merrill	–
Powell Street	Skidmore, Owings & Merrill	–
Civic Center	Reid & Tarics	–
16th Street Mission	Hertzka & Knowles	Theodore Osmundson
24th Street Mission	Hertzka & Knowles	Theodore Osmundson
Glen Park	Corlett & Spackman/Ernest Born	Douglas Bayliss
Balboa Park	Corlett & Spackman/Ernest Born	Douglas Bayliss
Daly City	Gerald M. McCue & Associates	Theodore Osmundson
Richmond	Maher & Martens	Royston, Hanamoto, Beck & Abey
El Cerrito del Norte	DeMars & Wells	Sasaki-Walker Associates
El Cerrito Plaza	DeMars & Wells	Royston, Hanamoto, Beck & Abey
North Berkeley	Kitchen & Hunt	Royston, Hanamoto, Beck & Abey
Berkeley	Maher & Martens	Royston, Hanamoto, Beck & Abey
Ashby	Maher & Martens	Royston, Hanamoto, Beck & Abey
MacArthur	Maher & Martens	Royston, Hanamoto, Beck & Abey
Concord	Gwathmey, Sellier & Crosby/Joseph Esherick & Associates	Anthony Guzzardo
Pleasant Hill	Masten & Hurd/Joseph Esherick & Associates	Anthony Guzzardo
Walnut Creek	Masten & Hurd/Joseph Esherick & Associates	Anthony Guzzardo
Lafayette	Gwathmey, Sellier & Crosby/Joseph Esherick & Associates	Anthony Guzzardo
Orinda	Gwathmey, Sellier & Crosby/Joseph Esherick & Associates	Anthony Guzzardo
Rockridge	Maher & Martens	Royston, Hanamoto, Beck & Abey
19th Street Oakland	Gerald M. McCue & Associates	–
12th Street Oakland	Gerald M. McCue & Associates	–
Oakland West	Kitchen & Hunt	Robert Kitchen
Lake Merritt	Yuill-Thornton, Warner & Levikov	Douglas Bayliss
Fruitvale	Reynolds & Chamberlain/Neill Smith	Anthony Guzzardo
Coliseum	Reynolds & Chamberlain/Neill Smith	Anthony Guzzardo
San Leandro	Masten & Hurd/Joseph Esherick	Anthony Guzzardo
Bayfair	Masten & Hurd/Joseph Esherick	Anthony Guzzardo
Hayward	Wurster, Bernardi & Emmons	Ralph Jones
South Hayward	Kitchen & Hunt	Robert Kitchen
Union City	Kitchen & Hunt	Robert Kitchen
Fremont	Kitchen & Hunt	Robert Kitchen

Source: Robert Betts, "Design of Bay Area Rapid Transit Stations" (Master's Thesis), University of California, Berkeley, 1973.

Construction Sequence and Duration[1]

Downtown subway construction usually began with the relocation of utilities. This was followed by the underpinning of buildings adjacent to the construction area. Where necessary (e.g., downtown San Francisco), vaults beneath the streets used for storage by adjacent stores were then closed. The support system for the construction area was built, followed by the decking over of the actual working area. Construction of BART proceeded underneath the decking. When construction was completed, the working area over BART was backfilled, the decks were removed and the street was restored for use by vehicles and pedestrians.

PLATE IV-1
CUT-AND-COVER CONSTRUCTION
DOWNTOWN, SAN FRANCISCO

[1] For additional information and analysis, see: Gruen Associates, Inc. and De Leuw, Cather & Co., Environmental Impacts of BART, Final Report, Chapter III. Document No. DOT-BIP-FR 7-4-77. Berkeley: Metropolitan Transportation Commission, August 1977.

Suburban station construction generally involved the following sequence of events: Existing facilities on the site of the station and parking area were demolished; utilities were relocated; the station shell, concourse area and platform were constructed; the parking lot and adjacent streets were completed and finally the area was landscaped. All construction was accomplished during daytime hours.

PLATE IV-2
SUBURBAN STATION CONSTRUCTION, CONCORD

The construction of aerial line segments occurred in several steps. First, interfering utilities were relocated, then street configuration changes were made. Next, the aerial structure support columns were installed, and the precast girders were placed. Finally, the track was laid, sometimes considerably after completion of the structure. Later, landscaping was added under separate contracts.

PLATE IV-3
AERIAL LINE CONSTRUCTION, WALNUT CREEK

Construction Duration

Construction duration for each of the 14 subway stations averaged 30 to 36 months from the time the contractor was given notice to proceed until the contractor received a notice of substantial completion. This did not include the period for street improvement projects.

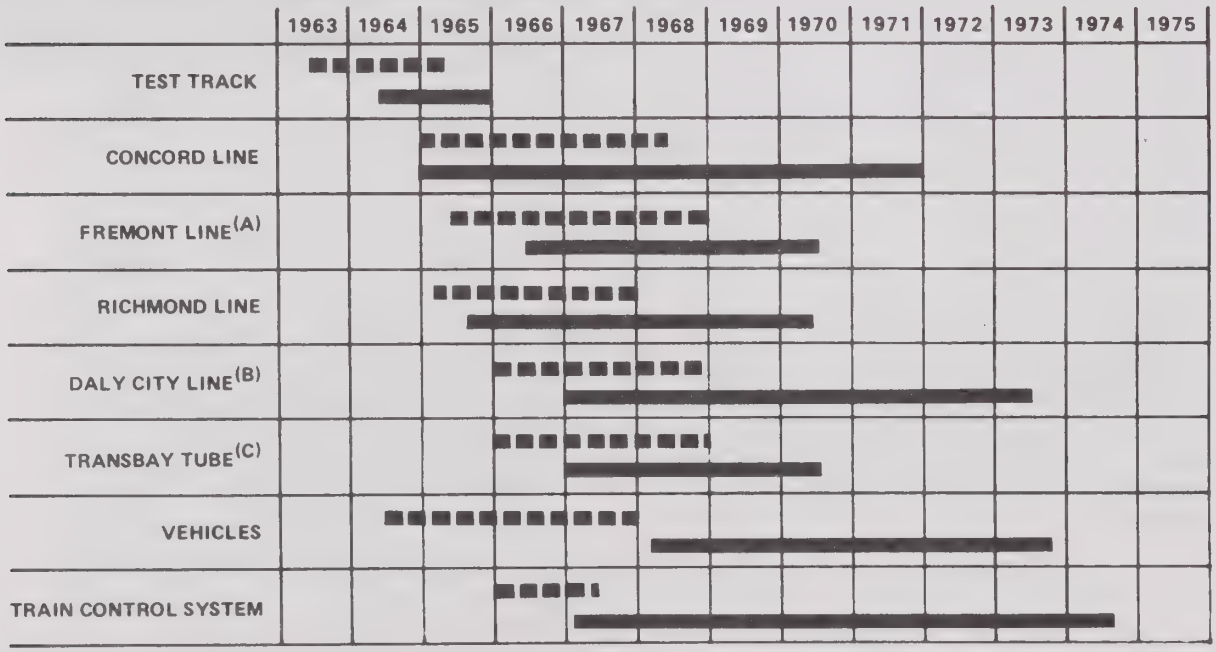
In conjunction with BART construction, some communities chose to make extensive improvements to the surrounding area. Most notable are the downtown street improvements in San Francisco, Oakland, Berkeley and Richmond. At these locations, publicly funded landscape and street surface improvements were made to accommodate the new pedestrian and vehicular patterns engendered by BART and to renew deteriorating areas. These street improvement programs varied greatly in scope, ranging from the $34.5 million project along two miles of Market Street in San Francisco to the more modest six-block mall created at the Richmond station for a cost of $300,000. Disruption along portions of Market Street lasted up to ten years (including street improvements and BART construction).

While the construction period for each of the 20 suburban stations averaged 24 months, the most disruptive period lasted only about 6 months. According to BART and its construction management contractors, the most disruptive period of aerial line construction usually lasted about two months. Major disruption from at-grade line construction usually lasted only a few weeks.

BART planners originally estimated that it would take about six years to build the major elements of the system. It actually took nearly 11 years. The last link of the BART system, the Transbay Tube, was opened in September 1974, more than 12 years after voters approved the system.

Figure IV-1 compares planned and actual construction schedules for the major BART capital projects.

FIGURE IV-1
PLANNED AND ACTUAL CONSTRUCTION SCHEDULES



A. INCLUDES 12TH STREET OAKLAND, 19TH STREET OAKLAND, AND MACARTHUR STATIONS.
B. INCLUDES EMBARCADERO STATION.
C. INCLUDES OAKLAND WEST.

KEY:
PLANNED CONSTRUCTION PERIOD
ACTUAL CONSTRUCTION PERIOD

Land Acquisition and Dwelling Unit Displacement[1]

Construction of the BART system required the taking of over 922 acres or 40 million square feet of land contained in some 3,482 parcels. A majority (56 percent) of the land taken was residential. Vacant land constituted 26 percent of the acquired land parcels, with commercial, industrial, mixed residential/commercial and institutional uses combining to form the remaining 18 percent of the land acquired. As part of the acquisition, some 3,004 dwellings were displaced. Precise numbers of persons affected are not known, but it appears that approximately 7,150 persons were displaced by BART.[2] The following tables give detailed breakdowns of land acquisition. Table IV-2 gives figures for each of the major line segments, while Table IV-3 breaks acquisition down by jurisdiction.

TABLE IV-2
ACQUISITION BY LINE SEGMENT

Line Segment	Land Take (Acres)	Parcels Acquired	Dwelling Units Displaced
Fremont to Oakland	296	943	484
Concord to Oakland	437	905	647
Richmond to Oakland	122	977	1,181
Downtown Oakland	31	244	404
Transbay Tube	1	20	4
Daly City to Downtown San Francisco	33	383	284
Downtown San Francisco	2	10	–
TOTAL	922*	3,482	3,004

* These figures are for "net" take. "Gross" take, which includes partial takes, easements and surplus land later sold, amounts to 968 acres.

Source: Blayney and Dornbusch, **BART's Consumption of Land and Property.**

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[1] For additional information and analysis, see: Blayney & Dornbusch, BART's Consumption of Land and Property, to be published in Spring 1978 as part of the BART Impact Program.

[2] Based on median number of persons per occupied unit for each of the affected jurisdictions.

TABLE IV-3
ACQUISITION BY JURISDICTION

Jurisdiction	Land Take (Acres)	Parcels Acquired	Dwelling Units Displaced
Albany	6	85	82
Berkeley	24	320	517
Concord	92	170	182
Contra Costa County	38	44	42
Daly City	14	268	155
El Cerrito	21	174	221
Fremont	85	282	6
Hayward	109	38	114
Lafayette	95	147	131
Oakland	114	29	920
Orinda	122	192	2
Richmond	63	171	170
San Francisco	22	936	129
San Leandro	16	98	27
San Lorenzo	18	196	120
Union City	31	230	19
Walnut Creek	52	102	167
TOTAL	922	3,482	3,004

Source: Blayney and Dornbusch, **BART's Consumption of Land and Property.**

Capital Cost and Funding Sources[1]

Capital Cost

The total forecast capital costs for BART are $1,635,600,000. These costs are allocated into various categories, and the proportion of each category is indicated in Table IV-4.

TABLE IV-4
BART TOTAL FORECAST CAPITAL COST

Cost Category	Total Forecast Cost (Thousands of Dollars)	Proportion of Total
Track and structures*	$ 662,587	40.5%
Stations*	332,389	20.3%
Yards and shops	22,721	1.4%
Electrification	37,281	2.3%
Train control	52,157	3.2%
Utility relocation	34,852	2.1%
Right-of-way	103,440	6.3%
Vehicle costs	175,065	10.7%
Engineering and management	137,169	8.4%
Pre-operating expenses**	77,939	4.8%
TOTAL	$1,635,600***	100.0%

* Cost estimates derived from contract amounts. Station construction contracts included short portions of adjacent track. Consequently, station costs are overstated and track costs correspondingly understated.

** Includes $25 million of capitalized early operating expenses.

*** Listed as "Current Forecast" in September 1975 BART Capital Program Report. Presumed to represent total estimated cost. Expenditures positively identified and allocated as of September 1975 are $1,544,304,000. The difference between that figure and the forecast total ($1,635,600,000) is $91,296,000, which is presumed to represent capital costs required to complete BART.

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[1] For additional information and analysis, see: Peat, Marwick, Mitchell & Co., Analysis of BART Capital Costs, Document No. DOT-BIP-WP 40-3-77. Berkeley: Metropolitan Transportation Commission, November 1977.

Comparison with Original Cost Estimates

The capital costs increased over the original estimate ($994 million) by nearly 65 percent. Major reasons for the cost overrun were changes in scope (such as the decision to go underground through Berkeley), a greater-than-anticipated rate of inflation, and delays in construction which compounded the effects of inflation.

TABLE IV-5
COMPARISON OF TOTAL FORECAST CAPITAL COST AND ESTIMATED COST

Cost Category	Total Forecast Cost (Thousands of Dollars)	1962 Estimated Cost (Thousands of Dollars)*	Percent Difference
Tracks and structures	$ 662,587	$ 417,465	+ 59%
Stations	332,389	122,792	+ 172%
Yards and shops	22,721	12,328	+ 83%
Electrification	37,281	58,676	– 37%
Train control	52,157	20,593	+ 160%
Utility relocation	34,852	44,131	– 23%
Right-of-way	103,440	88,561	+ 17%
Vehicle costs	175,065	71,200	+ 146%
Engineering and management	137,169	68,513	+ 101%
Pre-operating expenses **	77,939	7,000	+ 1100%
Contingencies	–	83,154	–
TOTAL	$1,635,600	$ 994,413	+ 64%

* Each cost category estimate includes a proportionate share of the $152,702,000 amount of inflation over the 1960 price levels used in preparing the estimate. The estimated $71,200,000 for vehicle costs includes inflation and therefore does not have a proportionate share of $152,702,000. No inflation factor was included for pre-operating expenses.

** See footnote, Table IV-4.

Source: **1975 BART Capital Program Report** and **1962 Composite Report.**

Funding Sources

At the time BART was proposed in 1962, it was to be funded from the sale of $792 million worth of general obligation bonds, to be repaid from property tax revenues, and was to receive $135 million of support from the California Toll Bridge Authority from toll revenue bonds. Rolling equipment was to be purchased with nearly $73 million worth of revenue bonds, based on operating revenues projected for BART service.

BART's actual financing is summarized in Table IV-6. An additional $12 million in general obligation bonds, to be repaid from the property tax of Berkeley alone, was issued to pay for the undergrounding of the line in Berkeley. The support from toll revenues has increased, as the cost of the tube and its approaches increased. With recognition of the unlikelihood of operating surpluses, the rolling equipment was financed with sales tax revenue bonds, rather than transit revenue bonds. Federal grants and miscellaneous other sources also contributed to BART's financing.

TABLE IV-6
SOURCES OF FUNDS

Sources of Funds	Amount
Proceeds of sale of general obligation bonds	$ 792,000,000
California Toll Bridge Authority	176,000,000
Proceeds of sales tax revenue	150,000,000
Earnings from temporary investments	111,000,000
Transit development	24,000,000
Miscellaneous income	51,000,000
Federal capital grants	315,000,000
Unidentified sources	16,600,000
TOTAL	$1,635,600,000

Source: BART Office of Public Information.

V. PHYSICAL FACILITIES

Introduction

This chapter describes the physical characteristics of BART: Its trackway, stations and adjoining facilities for its patrons, as well as the offices, shops and yards connected with its operation and maintenance activities. The information in this chapter combines with that in Chapter VI (describing BART's operating characteristics) to render a comprehensive view of the system's current physical and operational status.

General Characteristics

BART lines radiate from central Oakland in Alameda County and are identified by terminal stations: Daly City in the West Bay and Richmond, Concord and Fremont in the East Bay. Connecting the East and West Bay portions is a 3.6-mile transbay tube along the floor of the Bay between Oakland and San Francisco. There are 34 stations along the line: 17 in Alameda County, 8 in Contra Costa County, 8 in San Francisco City and County, and one in San Mateo County (Figure V-1).

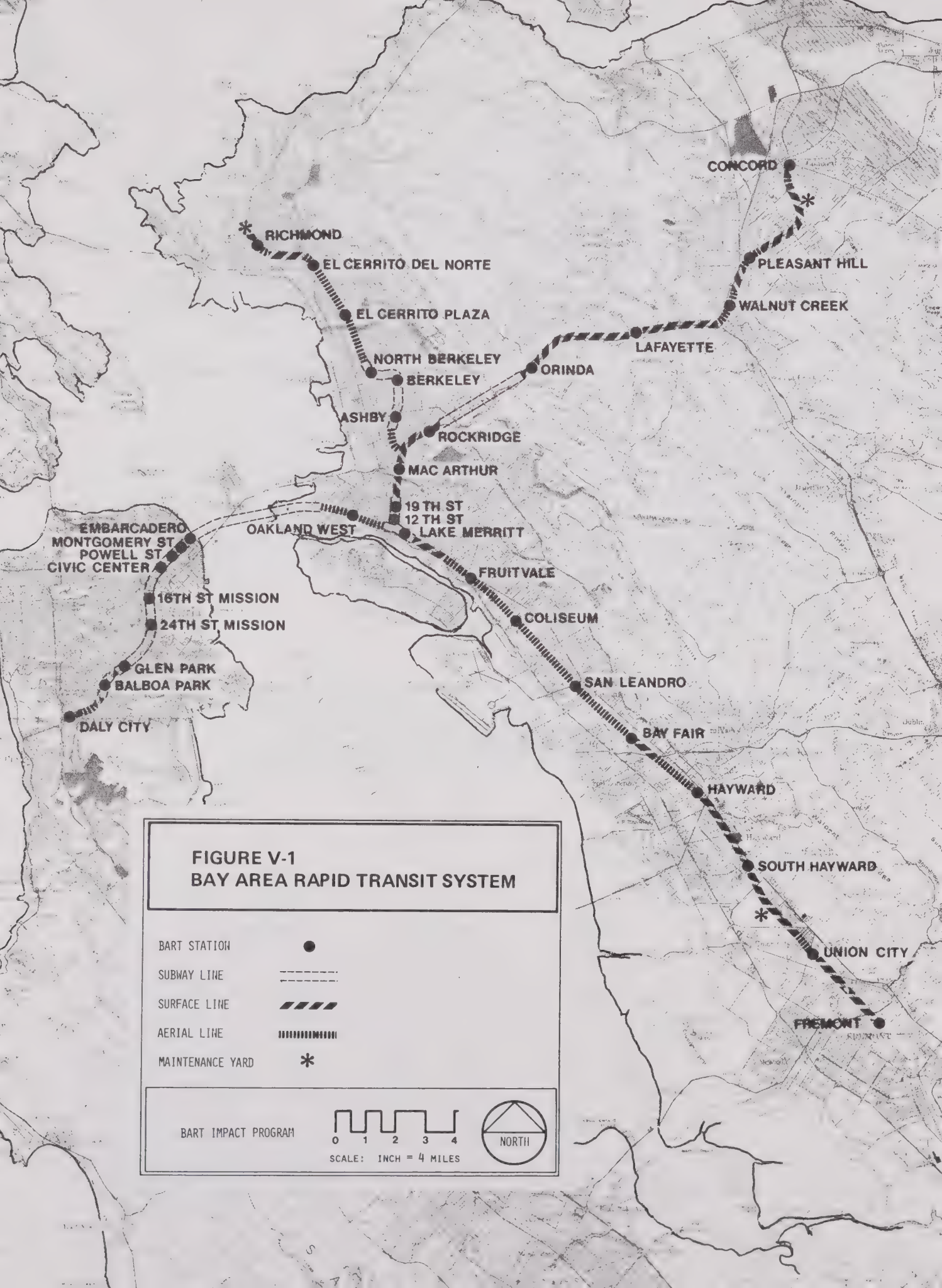
Trackway

The 71 miles of BART trackway lie in three basic configurations: Aerial (24 miles), at-grade (27 miles), and below ground (13 miles subway and 7 miles tube and tunnel). Table V-1 indicates configuration for each of BART's four lines.

TABLE V-1
BART CONFIGURATION BY LINE

BART Line	Aerial		At-Grade		Below Ground		Total Miles
	Miles	% *	Miles	% *	Miles	% *	
Fremont	11.97	46.5	11.74	45.6	2.05	7.9	25.76
Concord	3.11	16.4	12.12	63.7	3.71	19.5	19.02
Richmond	5.37	50.0	2.19	20.4	3.18	29.6	10.75
Daly City	3.11	20.1	1.06	6.9	11.29	73.0	15.46
TOTAL BART SYSTEM	23.56	33.2	27.11	38.2	20.23	28.5	71.00

* Row percent.


CONCORD
PLEASANT HILL
WALNUT CREEK
LAFAYETTE
ORINDA
RICHMOND
EL CERRITO DEL NORTE
EL CERRITO PLAZA
NORTH BERKELEY
BERKELEY
ASHBY
ROCKRIDGE
MAC ARTHUR
19 TH ST
12 TH ST
LAKE MERRITT
OAKLAND WEST
EMBARCADERO
MONTGOMERY ST.
POWELL ST.
CIVIC CENTER
16TH ST MISSION
24TH ST MISSION
GLEN PARK
BALBOA PARK
DALY CITY
FRUITVALE
COLISEUM
SAN LEANDRO
BAY FAIR
HAYWARD
SOUTH HAYWARD
UNION CITY
FREMONT
FIGURE V-1
BAY AREA RAPID TRANSIT SYSTEM
BART STATION
SUBWAY LINE
SURFACE LINE
AERIAL LINE
MAINTENANCE YARD
BART IMPACT PROGRAM
0 1 2 3 4
SCALE: INCH = 4 MILES
NORTH

Subway portions of the BART system are primarily in the high-density inner-city areas of San Francisco and Oakland. An exception is Berkeley, where the community voted a bond issue to pay the extra cost ($12 million) to place the system underground. Other exceptions are the Transbay Tube beneath the Bay, and the tunnel through the Berkeley Hills between the Rockridge and Orinda stations. Aerial configuration is often used where BART shares the right-of-way with another transportation facility, particularly along freeways and where cross traffic is heavy. At-grade (surface or embanked) configuration is most often found in relatively open areas and where cross traffic is generally light.

PLATE V-1
BART AERIAL TRACKWAY IN MEDIAN OF ARTERIAL HIGHWAY
GROVE STREET, OAKLAND

BART trains travel on continuous, welded rails fastened to a concrete roadbed. Special fasteners are used between rail and roadbed to provide electrical insulation and vibration dampening. The rails are spaced at 5 feet 6 inches gauge, wider than the standard 4 feet 8 1/2 inches gauge used in most American rail systems. This wider gauge is designed to stabilize the lightweight transit cars under high wind conditions and at high speeds.

PLATE V-2
BART AT-GRADE TRACKWAY ADJACENT TO RAILROAD AND ARTERIAL

BART's lines include a number of other features. There are 93 switch points (technically termed "crossovers" and "turnouts") occurring in groups of one to seven within short segments of trackway. All but 10 of these switch points are above ground. BART lines cross 31 bridges and overpasses (each of which is over 200 feet in length) in addition to its aerial lines. These typically involve a sudden change of configuration from embankment to elevated (bridge) structure. There are also a number of horizontal curves along the lines, but virtually all are of very long radius and banked for BART's operating speeds. Finally, there are 15 tunnel or subway portals.

Linear Park

In conjunction with BART aerial guideways in Albany and El Cerrito, a 2.7-mile park was built as an urban beautification demonstration project by the U.S. Department of Housing and Urban Development.[1] The prime objective of the project was to demonstrate how the rights-of-way under aerial structure could be treated so that the structure would be more aesthetically acceptable to the communities in which it is located and offer a more attractive view to the commuter.

The right-of-way on which the park is situated averages approximately 40 feet in width with some portions narrowing to 25 feet. Along the other side of the BART right-of-way is the Santa Fe Railroad. The linear park consists of a continuous meandering walkway periodically developed for sitting areas, play lots and places of assembly.

PLATE V-3
LINEAR PARK, ALBANY AREA

[1] U.S. Department of Housing and Urban Development, Linear Parkway. Washington, D.C.: U.S. Department of Housing and Urban Development, 1974.

Stations[1]

Station configurations match those of adjoining trackways. Of the 34 stations, 20 are above ground (seven at grade and thirteen aerial) and 14 are below ground. Nine of the below-ground stations are located in downtown areas. All stations have three main components within the station shell: An entrance, a mezzanine (or concourse) and a platform.

Entranceway

Subway stations are entered from the street by stairs, escalator or elevator, with the latter primarily used by handicapped and elderly persons. The Montgomery Street station in downtown San Francisco has eight entrances; other stations average four entrances. A few of the downtown San Francisco and Oakland stations have direct entrances from adjacent stores or office buildings.

At six of the subway stations, plazas of varying shapes and sizes have been built in conjunction with BART. These adjacent plazas provide an intermediate area between the sidewalk and the BART station. Plazas were built at both Mission Street stations, the Civic Center, Powell and Montgomery stations along Market Street, and at the 12th Street station in Oakland. Some open directly into the station's mezzanine, while others have a passageway from the plaza to the mezzanine.

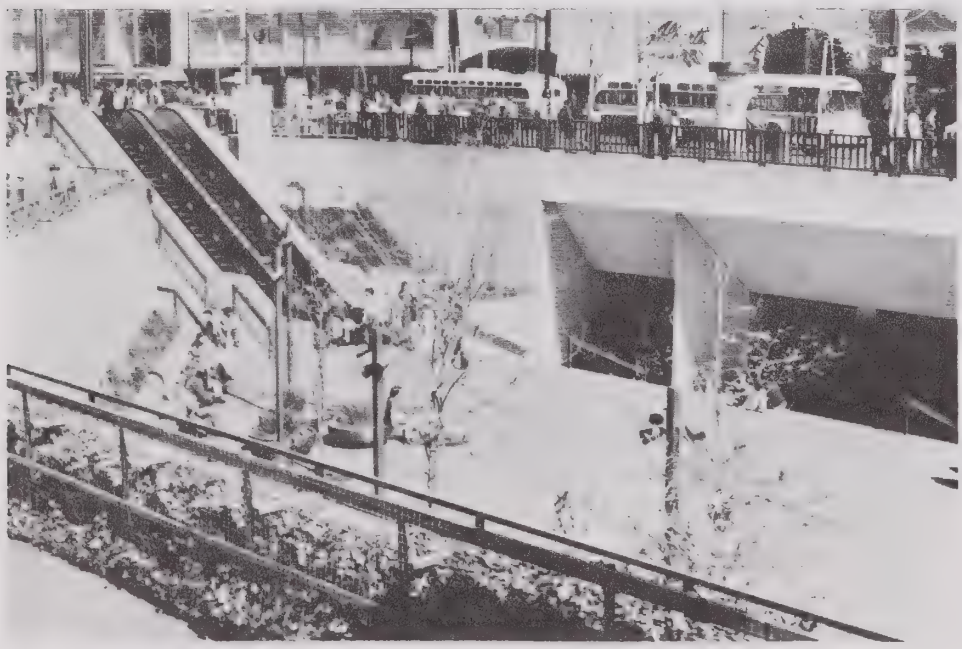


PLATE V-4
HALLIDIE PLAZA
POWELL STREET STATION
SAN FRANCISCO

[1] For additional information and analysis, see: De Leuw, Cather & Co., Environmental Impacts of BART: The User's Experience, Document No. DOT-BIP-TM 23-4-77. Berkeley: Metropolitan Transportation Commission, July 1977.

The 20 above-ground stations have entranceways directly from a parking lot or from an adjacent street. A few stations are combination above-ground and subway stations, with the mezzanine level above ground and the train platform below. Stations with this configuration include Glen Park, Balboa Park, Ashby and North Berkeley. The entrances to these stations are either directly from the street or from a parking lot, similar to the above-ground station configurations.

Mezzanine

The mezzanine is a transition area between station entry points and the stairs or escalators to train platforms. It functions to separate the activities involved in the complex process of moving large numbers of people through the station. Space is provided within the mezzanine for the entire fare collection process, the station agent, directional and informational signs and various amenities (such as concessions, toilets, telephones, and benches or seats) for passenger needs and comforts.

PLATE V-5
BART MEZZANINE, MISSION STREET STATION, SAN FRANCISCO

The Automatic Fare Collection (AFC) system consists of four main elements:

1. Ticket machine -- enabling patrons to purchase tickets in any amount from 25¢ to $20.00.

2. Change machines -- located adjacent to ticket machines and capable of changing coins and $1 and (in a few stations) $5 bills.

3. Automatic fare gates -- open and admit patron to paid area upon insertion of ticket; at exit, magnetically processes tickets to determine fare, prints remaining value, and opens to allow patron to exit to the free area. Directs patrons to "Addfare" machines nearby if ticket value is insufficient.

4. "Addfare" machines -- located inside paid area near ticket gates. On ticket insertion, it will compute the fare for the trip just taken, read the value of the ticket and indicate additional fare needed to open gates.

PLATE V-6
AUTOMATIC FARE COLLECTOR SYSTEM

In most cases, at least one ticket vendor and one change machine are located near each set of entrance gates. The number of ticket vendors installed was based on a formula of one vendor for every 75 people expected to board during the peak five minutes. No station has less than two ticket-vending machines, and the Montgomery Street station, the system's busiest, has 27 ticketing machines. Initially the ticket and change machines were separate. These are gradually being replaced by combination machines which were first introduced with the opening of the Embarcadero station.

The fare gates were intended to process 40 persons per minute. At least three were provided at each gate location -- one for exiting, one for entry and a third for the direction of major flow or as an emergency standby. Presently, no station has fewer than four fare gates, and the Montgomery Street station has 37.

Platform

The passenger boards or exits the BART train directly from or to the platform. It is reached from the mezzanine level by stairway, escalator or elevator. The primary design criterion for the platform is that it be 700 feet long, capable of handling a 10-car BART train.

PLATE V-7
STATION PLATFORM, MACARTHUR STATION, OAKLAND

Platform configuration varies somewhat, depending upon site-specific design needs. Subway station platforms are all of the center-loading type, except for the Oakland 12th Street and 19th Street platforms. These are of a two-level, side-loading design which stays within the right-of-way of the narrow street above. The width of the subway platforms varies from 22 1/2 feet to 35 feet, with at least 8 feet between obstructions (e.g., a column or an escalator) and the edge of the platform.

Above-ground stations have either side-loading or center-loading platforms. When the sets of track must be close together (about 14 feet from center to center), usually because of space limitations, a side-loading scheme is used. Here the platforms are approximately 18 feet wide, for the middle 280 feet, narrowing to about 12 feet for the remaining 210 feet at each end. When the sets of track can be further apart (usually 36 feet from center to center), a 25-foot-wide center platform configuration is used. There are ten above-ground stations of each type.

Open areas for patrons amount to approximately 70-75 percent of the total platform space. The remaining space is taken up by escalators, stairwells, an elevator, 2-foot-wide warning strips, columns, benches, directional signs, telephones and trash receptacles. One station, Powell Street, provides coin-operated electronic games for patrons to use while waiting for trains. All above-ground stations have a canopy covering at least the central portion (280 feet) of the platform and, in addition, have vertical wind screens for weather protection.

Electronic signs suspended from the platform ceilings transmit information about arriving trains. Final destination of each train is displayed on these Train Destination Signs (TDS) as the train approaches the platform. The signs also indicate the length of approaching trains and which part of the platform should be used for boarding.

Facilities for Handicapped Patrons[1]

Many of BART's original design features made provisions for physically handicapped persons. These included high-level platforms so that passengers do not have to climb steps to board trains; escalators for all vertical distances of 12 feet or more; and, train doors and station entry and exit gates wide enough to accommodate wheelchairs.

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[1] De Leuw, Cather & Co., The User's Experience, Chapter VII.

In 1965, the BART District adopted official design standards conforming in many respects to American Standards Association specifications for making buildings and localities more accessible and usable by physically handicapped people, but the 1965 design standards omitted provision for full accessibility to BART by people confined to wheelchairs. California state laws enacted in 1968 required that BART's design standards be modified in two major areas. The legislation required that (1) elevators be included in stations, and (2) restrooms be redesigned to accommodate persons in wheelchairs. In September 1969, the BART District Board voted to install elevators in all BART stations to allow full access to the system by persons confined to wheelchairs. Consequently, elevators have been installed in all BART stations.

PLATE V-8
HANDICAPPED PERSON BOARDING BART TRAIN

Access to BART

BART patrons come and go to the stations in four basic ways: By bus, in an auto, on bicycles or motorcycles, or on foot.

Bus Access to BART

Aside from a few express bus routes which are operated by AC Transit under contract to BART, all the feeder bus services to BART are operated by agencies which are organizationally and financially separate from BART. The principal operators of bus service to BART are AC Transit in the East Bay and MUNI in San Francisco.

Some feeder bus service is provided to all BART stations. AC Transit operates most of the feeder bus service in the East Bay, but city-operated bus systems provide services to the Walnut Creek and Union City stations. The Santa Clara County Transit System operates one route to the Fremont BART station. In the West Bay, most feeder services are provided by the MUNI system. The San Mateo Transit District operates feeder bus services to the Daly City BART station, which is located outside the MUNI service area. The remaining feeder bus services are small, privately-operated shuttle services.

Travelers using AC Transit or MUNI to reach BART pay only half the normal round-trip bus fare. Different transfer procedures have been adopted for the two systems. AC Transit passengers pay the regular bus fare for their trip to the BART station. On their return trip, they can obtain a free transfer ticket in the BART station for a bus ride to any destination within the same fare zone. MUNI passengers can purchase a two-part ticket for the cost of one regular ticket ($.25) in BART stations. One part of the ticket is valid for the transfer from BART to MUNI, and the second part is valid for a return trip. The ticket bears the name of the BART station where it was issued and is valid for three days.

Bus loading zones were included in the design of most suburban stations. These zones can accommodate two to four standard-size transit buses. Private shuttle buses also use these loading spaces. Central city stations are served by existing bus loading zones on streets adjacent to the station. At almost all bus stops located away from the protection of the station entrances, open-air shelters have been installed which shield the patrons from the elements.

PLATE V-9
BUS LOADING AREA, FRUITVALE STATION, OAKLAND

Automobile Facilities at BART Stations

Parking lot facilities were built at 23 of the 34 stations, primarily at above-ground stations in suburban areas. Only one downtown station (Lake Merritt at BART headquarters) has parking facilities. Present lot capacities range from 197 spaces at Lake Merritt to 1,627 spaces at Daly City (Table V-2), covering areas of two to eight acres. Total parking capacity (including both all-day and midday spaces) at all 23 stations is 20,128 spaces. All parking facilities are single-level, open lots with the exception of Daly City, where a multi-level parking structure has been built. Parking is free at all lots except Lake Merritt, where a 25¢ charge is made. In addition to all-day parking, separate areas within lots are set aside for: Midday parking (9:00 a.m. to 4:00 p.m.), kiss-and-ride areas serving auto passenger drop-offs and pick-ups, and special automobile stalls, close to the station entrance, serving handicapped patrons.

PLATE V-10
BART PARKING LOT
HAYWARD STATION

TABLE V-2
BART PARKING LOT SPACES, OCTOBER 1977

Station	Total Spaces	Mid-Day Stalls	All-Day Parking Available to Commuters
Concord	1,074	76	998
Pleasant Hill	1,483	109	1,374
Walnut Creek	1,156	118	1,038
Lafayette	982	29	953
Orinda	997	59	938
Rockridge	776	26	750
MacArthur	487	46	441
Oakland West	403	20	383
Richmond	754	36	718
El Cerrito del Norte	1,054	139	915
El Cerrito Plaza	509	48	461
North Berkeley	500	95	405
Ashby	560	19	541
Fremont	835	62	773
Union City	826	63	763
South Hayward	880	91	789
Hayward	861	65	796
Bayfair	1,408	114	1,294
San Leandro	1,106	78	1,028
Coliseum	923	77	846
Fruitvale	730	121	609
Lake Merritt	197	0	197
Daly City	1,627	252	1,375
SYSTEM TOTAL	20,128	1,743	18,385

Source: BART Office of Research.

Bicycle Facilities

Bicycle racks and/or lockers are provided at most of the suburban stations and some of the downtown stations. Total racks number approximately 1,200, and there are 650 lockers. Over 500 persons ride their bicycles to BART on an average summer weekday. About 200 persons per week take bicycles on BART. Standard bicycles are allowed on BART by permit during non-rush hours but only in certain locations on the trains. Folding bicycles are allowed in the system without permit or restriction.

Service Facilities

In addition to its stations and trackway, BART's facilities include an administration building, three train-vehicle maintenance and storage yards, and one shop for maintenance and repair of the trackway and structures.

The BART administration building is located in Oakland adjacent to the Lake Merritt station. Between 400 and 450 persons are employed there, mainly in administrative positions. In addition, the automatic train control center and the systemwide communication network are housed in the eight-story building. Off-street visitor parking is provided across the street from the building, and employee parking is located about four blocks away beneath a freeway.

Inspection, service and storage of BART trains occur in three locations: Richmond, Concord and Hayward. These yards and shops occupy from 20 acres to nearly 50 acres, and up to several hundred persons are employed at each facility. Work is done on a 24-hour basis, seven days a week. Major activities at each facility include preventive and unscheduled maintenance, car damage repairs (heavy repair work is done only at Hayward), car modification and parts replacement, cleaning, assembling and dispatching of trains, and storage of vehicles when not in operation. Each yard can store approximately 160 cars. At the Hayward yard a two-and-one-half-mile engineering test track is available (parallel to the main line) for testing of new cars or repaired cars.

PLATE V-11
HAYWARD YARDS

Personnel based at the Oakland Shop, located between the Lake Merritt and Fruitvale stations, are responsible for maintenance and repair of all trackway and structures, electrical supply and distribution systems, and repair and service vehicles. Approximately 300 to 400 people work out of this facility, which includes complete machine and fabrication shops. These facilities are located in an industrial area adjacent to a freeway and railroad.

Electrical Distribution Facilities

Power supply for the BART system is direct current electrical energy purchased at seven locations as alternating current (ac) and then rectified to direct current (dc) at 37 substations. These electrical substations are located adjacent to each of the 34 BART stations and one each in the three maintenance and repair yards. The total installed capacity of each substation is 232 megawatts. Power to the trains from the trackside is supplied by a 1000-volt third rail system.

VI. BART OPERATIONAL FEATURES

Introduction

The characteristics of BART's operations and patronage are discussed in this chapter. Descriptions of the train vehicle, the power and braking systems, the highly sophisticated automatic train controls, and the system's use of energy are followed by descriptions of BART's service characteristics and patronage (including levels of ridership, trip characteristics, and the socioeconomic makeup of BART ridership). Finally, discussions of the system's safety/security and its operating costs are presented.

Train Vehicle

Rohr Corporation assembled 450 vehicles for BART. The cars are made of aluminum and are lightweight (57,000-59,000 pounds when empty). BART trains use two types of vehicles, designated as "A" and "B" cars. The 75-foot-long "A" cars are those with an attendant's cab and automatic train control (ATC) equipment. Each train must have ATC units at both ends for reversible operation under automatic control. "B" cars are 70 feet in length and have no train control equipment; they are placed in the middle of the train, in groups of one to eight cars. "A" and "B" cars are assembled on the same main body structure. Cars are mounted on two trucks with two axles per truck. Each car is powered by four 150-horsepower motors, mounted one to each axle.

PLATE VI-1
BART CAR WITH ATTENDANT'S CAB

Propulsion power is provided by a 1,000-volt direct current (dc) third rail. The system will accelerate trains from a standstill to 60 miles per hour in 20 seconds and decelerate trains from 80 miles per hour to a stop in 27 seconds. Maximum acceleration is 3.0 mph per second. The train vehicles are equipped with a dynamic (regenerative) braking system (which uses the propulsion motors as generators to return power to the third rail and to brake the train) and a friction braking system. In general, the dynamic braking system is used at speeds above 15 miles per hour, and the friction braking system is used at slower speeds and as an emergency and parking brake system.

Each car can accommodate 72 seated passengers and approximately 120 to 150 standing passengers. There is a continuous aisle along the length of the train, enabling passengers to move from car to car when the train is in motion. Foam-padded seats are cantilevered from the side walls, arranged in two-by-two fixed configuration, with half of the seats facing each end of the car.

PLATE VI-2
INTERIOR OF BART CAR

The cars have wall-to-wall carpeting. Temperature and humidity are controlled by a multi-zone air conditioning system. There are two entrances on each side of the car; those facing the platform open and close automatically at each station unless controlled by a train attendant. A public address system is used by the train attendant to announce station stops and to advise passengers on transferring between lines. To further aid passengers, four large system maps are located on the walls near each door. An intercom system links each car to the control cab of the train. Standees' overhead grab rails were installed on all cars after original delivery of the vehicles to BART.

Automatic Train Control System

The Bay Area Rapid Transit system is a highly automated operation. The automatic train control (ATC) system automatically dispatches and routes trains, regulates their speeds, and maintains safe distances between them. It also controls the opening and closing of doors, the duration of station stops, and the display of information on platform signs. Equipment for the ATC system consists of:

1. A central computer control complex with a redundant backup computer, display boards and consoles ("Central Control").

2. Thirty-six local train control centers (one at each station and yard), with associated wayside equipment.

3. Vehicle control equipment on-board all trains.

4. A transmission system to relay information between the central control complex and 45 remote locations (which include the 36 local train control centers).

PLATE VI-3
CENTRAL COMPUTER CONTROL COMPLEX, BART HEADQUARTERS, OAKLAND

The ATC system is intended to ensure the coordinated operation of all trains. At the start of each service day, a predetermined schedule of departure times from the four terminals of the system is established for each of the trains scheduled to operate. The central computer constantly monitors the progress of trains compared to the schedule. When deviations from the schedule occur, the computer attempts to adjust the speed and station stop times of all affected trains until operations again conform to the schedule.

Each train is assigned a unique identification number for route control. This identification is transmitted continually by the train to the control centers. At interlockings (i.e., where tracks diverge and converge), the transmitted identification number initiates an automatic route request; the local control center verifies that no route conflicts exist before track switches are aligned for the requested route. Central Control can cancel a route request and substitute an alternate request if necessary because of track blockage or maintenance work.

If some part of the ATC system malfunctions, trains can be routed manually from each of the local train control centers. The train attendant can override automatic controls by commanding an emergency stop if he observes some unsafe condition such as an obstruction of the right-of-way. In the event of a malfunction, a manual mode of operation can also be put into effect under direction of Central Control.

The 71-mile BART system is divided into sections of track called "blocks" which are 11 feet to 1,100 feet long. Electric signals carrying speed commands are transmitted through track circuits within each block. These circuit signals are transmitted to on-board train equipment via coils mounted in front of the train's front wheels which sense the current in the rails. The on-board train equipment compares the speed command with the train's actual speed and modifies the speed accordingly. The speed command associated with a given block can be modified by Central Control. When a train enters a block, the signal is diverted from the rails through the wheels and axles of the train, and an "occupancy" is indicated. A "safe speed profile" is then generated behind the occupied block to maintain a safe distance between the train and the following train.

Trains are stopped at the proper position on station platforms by signals transmitted to the train from wayside equipment on the approach to each station. This equipment electronically determines the train's position and speed and causes the brakes to stop the train smoothly at the correct point. Train doors are opened and closed in accordance with commands from the central computer. Dwell times assigned for each station may be adjusted in accordance with schedule needs. The automatic door controls may be overridden by the train operator.

To ensure train safety in the event of train detection failures, four backup systems of increasing levels of sophistication have been or are being developed and implemented by BART. Each of these systems is described below.

- Manual Block Procedure. A manual backup procedure was first adopted to allow BART service to begin. Under this procedure, supervisors were assigned to every second station platform on the system and at the four terminus stations. The platform supervisor's job was to phone ahead to ensure that the track was clear two stations forward on the line before releasing the train at his station. All lines of the system with the exception of the transbay link were opened to revenue service under the manual block procedure. Train operations were significantly constrained under the manual procedure since a minimum headway of about 10 minutes was implied.

- Computer Automated Block System II (CABS-II). This system uses BART's central computer to automate the manual block procedure, still maintaining a two-station separation between trains. In October 1973, BART began operating trains on the Concord line under CABS-II in parallel with the manual block procedure. After several months of demonstration, the California Public Utilities Commission (PUC) granted BART permission to operate the Concord line under CABS-II alone. Authorization to operate under CABS-II was given in April 1974 for Richmond-Fremont service and in May 1974 for San Francisco-Daly City service. Although CABS-II performed more efficiently than the manual block procedure, operations were still restricted to a minimum headway of about 10 minutes.

- Computer Automated Block System I (CABS-I). Operation of BART at headways of about 5 minutes was considered necessary for transbay operations. (Under CABS-II, if trains from both the Concord and Fremont lines were to use the transbay tube, minimum headways of about 20 minutes on each line would have been implied. This was considered unacceptable.) Consequently, BART began development of CABS-I. This is a backup system which operates in a manner similar to CABS-II, but permits a minimum train separation of only one station, or approximately 5 minutes. (Control computer software logic ensures that a train is held at a station platform if the previous train has not been positively detected departing the station ahead.)

  Under CABS-I, a specially designed "zero speed gate" was installed at the exit from each station to overcome possible problems with trains running through stations without stopping or being inadvertently released by the computer without proper clearance. The function of the "zero speed gate" is automatically to stop any train that inadvertently runs through a station and holds it until the next station down the line has released its train. The PUC granted approval for CABS-I train operations on all lines of the system, except the transbay line, in July 1974.

  Two additional modifications to CABS-I were required before transbay BART service could begin. To allow 5-minute headways in the long transbay tube, "pseudo-stations" were established at intermediate points in the tube. Second, a method of regulating train movements through the track interlocks at the Oakland Wye was incorporated in the computer backup system to avoid the possibility of trains merging at the same time.

In August 1974, BART successfully completed a full-scale, systemwide test of CABS-I. Several weeks later, the PUC approved systemwide operations using the CABS-I system, thereby allowing BART to start transbay service from two of the three East Bay lines at 6-minute intervals in September 1974.

- Sequential Occupancy Release System. Further expansion of BART service, including direct Richmond-Daly City service and a reduction in the intervals between trains, is contingent upon the PUC's approval of the permanent backup control system being implemented by BART to replace CABS-I. The Sequential Occupancy Release (SOR) system employs a series of minicomputers installed in redundant pairs at each of 26 control points to provide for automatic check-in and check-out of trains through blocks. Once a train has been detected in a block, the track circuit for that block remains "locked up" until the train is detected in the next block. Although SOR normally locks up two block circuits at a time, the system will not result in significant degradation of the performance level provided by the basic ATC system. It is intended that, when the SOR system is in full operation, BART will have a capability for headways as low as 2 minutes. As of the date of this report, initial installation and testing of the SOR system is underway.

Service Characteristics

From the date of BART's opening for revenue service in September 1972 until January 1976, BART trains ran five days a week between 6:00 a.m. and 8:00 p.m. In January of 1976 permanent night service went into effect, extending service to 12:00 midnight. Saturday service between 9:00 a.m. and 12:00 p.m. is to begin as a permanent feature on January 1, 1978, and Sunday service is scheduled to begin in June 1978.

Currently, three direct BART services are operated: Fremont to Daly City, Concord to Daly City and Fremont to Richmond. In addition, one train a day runs in each direction between Richmond and Daly City to provide service to a major federal office building in Richmond. Direct service between Richmond and Daly City throughout the day is planned to begin by March 1978; at present, travelers going between these two stations must change trains in Oakland.

BART operates on scheduled headways rather than a fixed time schedule. On each of the three services, headways between trains are 12 minutes at the end of the lines and 6 minutes in downtown San Francisco and Oakland. Following the afternoon peak period and on Saturdays, headways are lengthened to 20 minutes. A total of 33 trains a day operate. Three-minute downtown headways during peak periods are planned for the future. This implies 9-minute end-of-line headways if service is equal on all lines. However, future service levels may be planned to reflect demand levels, with more frequent trains on lines with heavy demand, and less frequent service on lines with less demand and during off-peak periods.

Train length also varies according to demand. During weekday peak periods the maximum 10-car train is used. During other periods typical train size varies from 3 to 7 cars. If longer trains are needed off-peak for certain lines or for special events, they are run.

Normal maximum operating train speed is 70 miles per hour, with an average speed of 36 miles per hour including station stops. Two types of strategies can be employed to modulate train performance. One strategy is to increase or decrease the dwell time (normally 15 seconds) that trains remain in stations. The other strategy is to modulate the operating speeds and acceleration rates. The speed margin allows trains that are running behind schedule to be speeded up to a maximum of 80 miles per hour. In addition, two acceleration rates can be employed, one at 3.0 miles per hour per second and one at 1.5 miles per hour per second.

BART Fares

BART's fares range from $.25 to $1.45; the chief determinant of the fare is the distance traveled (Table VI-1). The fare schedule introduced when BART began operations in 1972 was retained until November 1975. In general, the new fares are higher than the original fares for long trips, and lower for short trips. The average fare now is 21 percent greater than the average of the original fares.

TABLE VI-1
BART FARE STRUCTURE

Fare Component	Fare
Trips up to 6 miles [a]	30 cents
Trips from 6 to 14 miles	40 cents + 5 cents/mile
Trips from 14 to 20 miles	80 cents + 2 cents/mile
Trips over 20 miles	92 cents + 1 cent /mile
Transbay surcharge [b]	25 cents
Daly City surcharge [c]	15 cents
Scheduled speed component	+/– 2 cents/minute
o Resulting highest fare	$1.45
o Average fare (weighted by expected patronage)	76 cents

a CBD trips under 2 miles, 25 cents; trips within East Bay suburban zone (Concord-Orinda, Fremont-Bayfair, Richmond-Ashby), 30 cents.

b Transbay trips from R-line stations involve transfer, and thus surcharge remains at 15 cents.

c Does not apply to transbay trips.

Typical fares from downtown San Francisco to various destinations are: $.55 to Daly City; $.75 to Oakland; $1.00 to Richmond; $1.20 to Lafayette; $1.35 to Concord; $1.10 to San Leandro; and $1.40 to Fremont.

BART has special fares for children, handicapped persons and senior citizens 65 and over. Discounted tickets must be purchased at participating local bank branches only, not at BART stations. The special fare rates are as follows:

- Children 4 and under ride free.
- Children 5 through 12 can purchase a red ticket worth $6.00 for $1.50.
- Handicapped persons can purchase a red $6.00 ticket for $1.50.
- Senior citizens 65 and over can purchase a green ticket worth $6.00 for $.60.

Patronage[1]

Average daily ridership on the BART system has steadily increased since revenue service began on the Fremont line in September 1972 with about 17,000 patrons per day. Within a year's time, when three Easy Bay lines were in operation, average daily ridership was about 35,500 trips. This increased to 68,000 with the start of service on the line between San Francisco and Daly City in November 1973. Following the start of transbay service in September 1974, ridership increased to about 120,000 daily trips. With an increase in BART fares effective November 3, 1975, average daily ridership dropped from 125,000 trips in October to 121,000 trips in November. With the start of evening service on November 28, 1975, ridership increased again from 121,000 trips in November to 128,000 trips in December 1975.

During the months of April and May 1976, a strike of San Francisco city craft workers (from March 31 through May 8, 1976) curtailed MUNI bus service. Consequently, average daily BART ridership increased from 123,000 trips in March to 145,000 trips in April 1976, with all of this increase occurring in West Bay ridership. Since the opening of the BART Embarcadero station on May 27, 1976, average daily ridership on the system has remained fairly steady, varying between 130,000 and 140,000 trips per day (Figure VI-1). Between September 1972 (beginning of revenue service) and October 1977, over 125 million passenger trips have been made, covering nearly 2 billion passenger miles (Table VI-2).

TABLE VI-2
SELECTED BART OPERATING DATA: 1972-1977

Calendar Year	Train Miles[b]	Car Miles[c]	Passenger Trips[d]	Passenger Miles[e]
1972[a]	330,454	935,279	1,200,659	19,690,807
1973	1,773,239	7,617,638	8,412,878	114,372,534
1974	3,236,410	16,946,757	21,925,909	293,552,538
1975	4,180,685	23,416,843	31,088,627	467,283,500
1976	4,200,162	22,136,116	34,023,973	449,558,000
1977[a]	3,212,626	18,314,756	28,436,041	367,276,500

a September through December1972; January through October 1977.

b Train miles: total number of miles logged by all of the trains in revenue service.

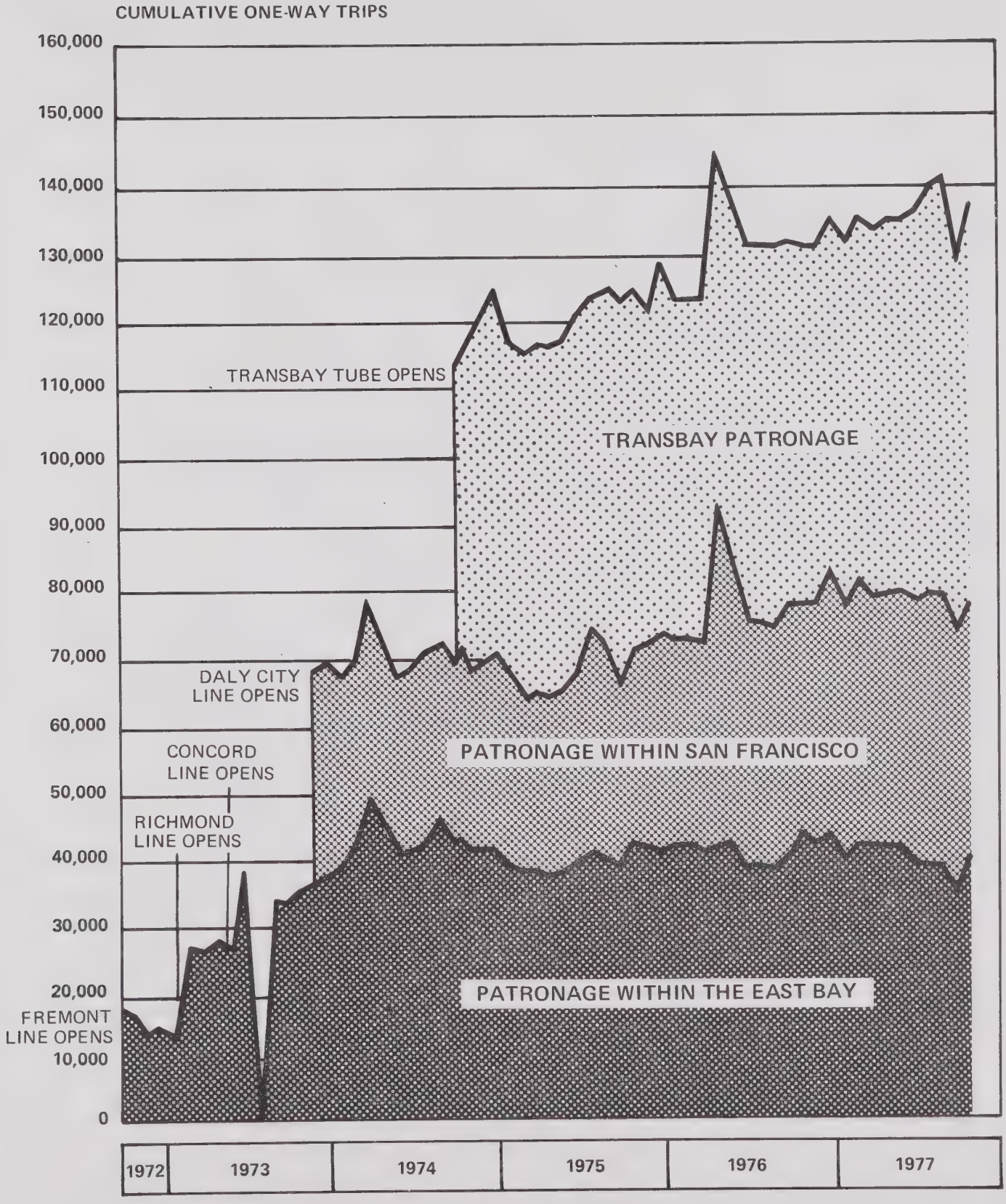
c Car miles: total number of miles logged by all of the cars in revenue service.

d Passenger trips: total person trips registered at exit gates.

e Passenger miles: total number of miles traveled by passengers on BART based on daily measures, including an estimate of excursion riding.

[1] For additional information and analysis, see: Peat, Marwick, Mitchell & Co., Travel in the BART Service Area, Document No. DOT-BIP-WP 35-3-77. Berkeley: Metropolitan Transportation Commission, September 1977.

FIGURE VI-1
CUMULATIVE AVERAGE DAILY PATRONAGE BY MONTH (1972-1977)



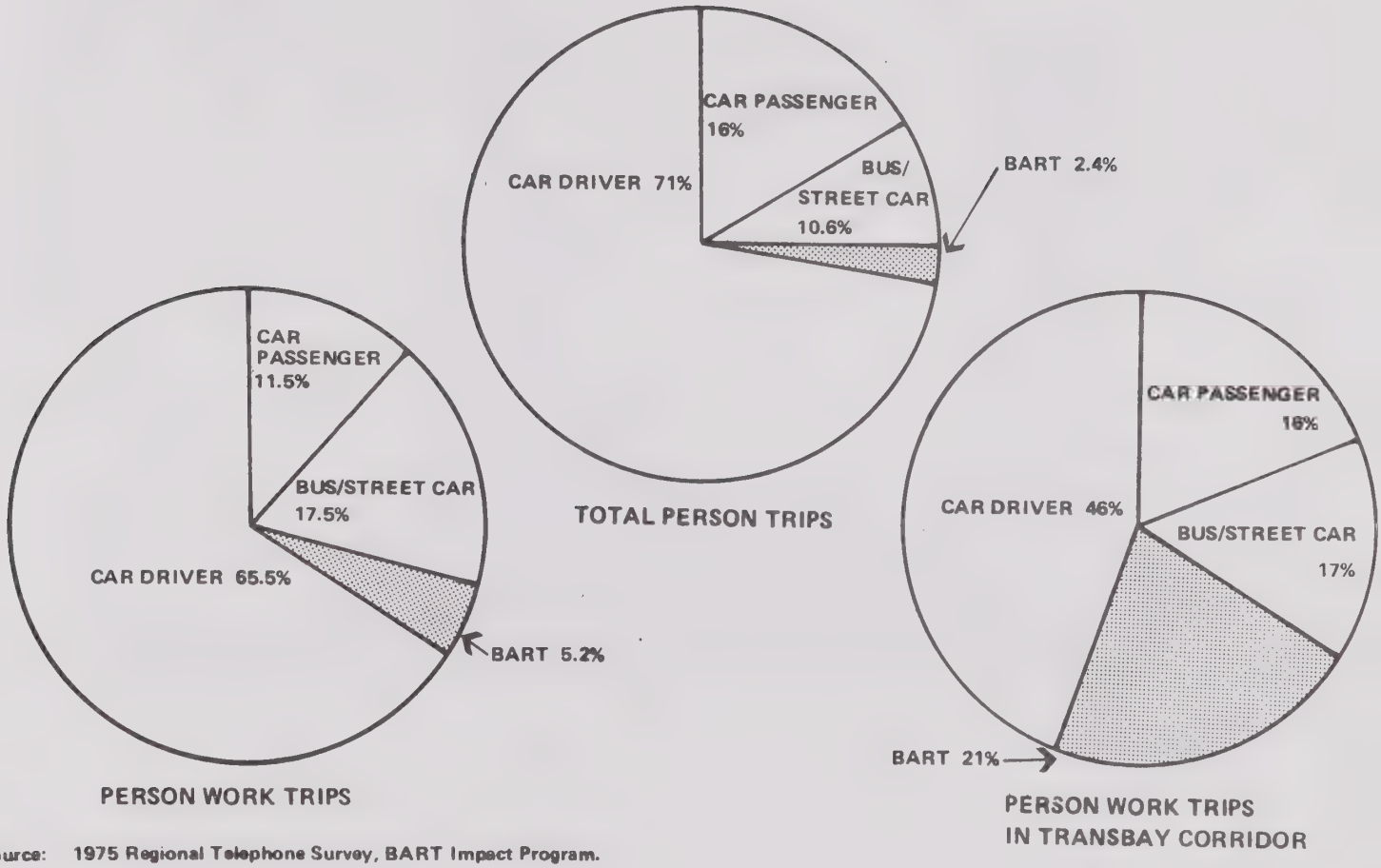
On a station-by-station basis, the Montgomery station in downtown San Francisco is the busiest, with an average daily total patronage in September 1977 of 15,998 (total person-trips registered at exit gates where fare is collected). The least used station is Ashby in Berkeley, with an average daily patronage in September 1977 of 908.

BART's Share of Vehicular Travel

Figure VI-2 summarizes the mode and purpose of travel for all weekday trips made by people living in the BART service area (Alameda, Contra Costa, San Francisco Counties and northern portions of San Mateo County). For trips of all purposes, BART's share is 2.4 percent. Bus (or streetcar) trips account for another 10.6 percent, and the remaining 87.0 percent are by automobile (or truck). However, for trips to and from work, transit's share, particularly BART's, is much higher. BART carries an estimated 5.2 percent of all work trips, bus 17.7 percent, and automobile (car driver and car passenger) the remaining 77.1 percent. Transit also carries a fairly large share of trips made to and from school or college (BART 2.9 percent, bus 18.6 percent). Well over 90 percent of trips for all other purposes are made by automobile.

In the transbay commute corridor BART was intended to serve particularly well, the automobile again accounts for the majority of trips, but transit, and particularly BART, plays a much more prominent role. A BART Impact Program survey of transbay travel conducted in October 1974, shortly after the start of transbay BART service, showed that a total of approximately 136,000 person-trips were made in the San Francisco-Oakland Bay Bridge corridor during the daytime (6:00 a.m. to 8:00 p.m.) for all purposes. Of these, 19 percent were made by BART, 13 percent by bus, and 68 percent by automobile. Considering only transbay trips to or from work, 21 percent were by BART, 17 percent by bus, and 62 percent by automobile. (Changes in transbay travel volumes since the time of the 1974 survey have probably not varied these percentages very much.) Thus, something like one work trip in five between San Francisco and the East Bay suburbs is being made by BART.

FIGURE VI-2
BART'S SHARE OF TOTAL TRAVEL MARKET



Source: 1975 Regional Telephone Survey, BART Impact Program.

Trip Characteristics

BART patronage is highly oriented towards peak period journeys to and from work places in the central business districts of San Francisco and Oakland. About 52 percent of BART trips are made in the morning (7:00-9:00 a.m.) and evening (4:30-6:30 p.m.) peak periods (Figure VI-3). BART serves primarily work trips in the morning peak period, with trip purpose greatly varying during the midday off-peak period. Table VI-3 shows these variations.

FIGURE VI-3
PATRONS ENTERING STATIONS BY TIME OF DAY (MAY 1977)

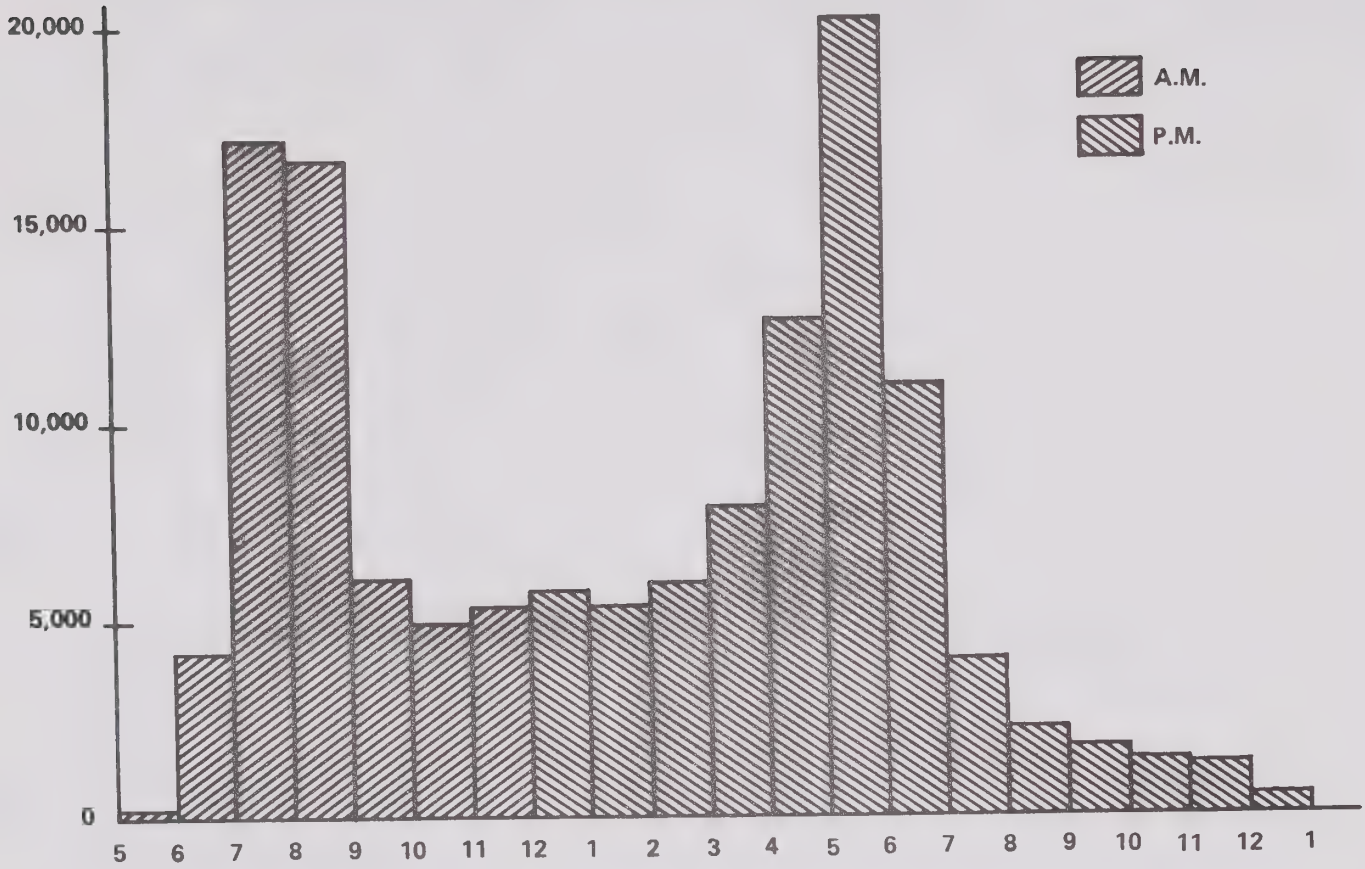


TABLE VI-3
TRIP PURPOSE BY TIME OF DAY

Time of Trip	Purpose				
	Work	Business	School	Personal Business	Other
Morning peak, 6 a.m. to 9 a.m.	87.0%	0.2%	8.9%	1.3%	2.6%
Mid-day off-peak, 9 a.m. to 3 p.m.	27.8%	6.6%	15.6%	22.3%	27.7%

BART's principal destinations are the four downtown San Francisco stations. Those stations comprise one-third of the total number of station exits on the system all day, and two-thirds during the morning peak. Reflecting the suburban-to-downtown orientation of trips, the average trip length on BART is about 13 miles, with trips from the Concord line averaging over 22 miles. The average BART trip takes 46 minutes door-to-door, of which 33 minutes are spent on the train. Transbay trips average 54 minutes door-to-door, Easy Bay trips 46 minutes and West Bay trips 34 minutes.

Ridership varies considerably between different segments of the system. A little less than one-half of all BART trips are made through the Transbay Tube. Patronage is highest between stations on the Concord line and San Francisco, and lowest for travel among the five Oakland stations.

Patron Characteristics

Comparison between BART riders and the general population in the three counties in which it operates have been made relative to the following socioeconomic factors: Age distribution, educational level, household income and ethnic/racial composition. Differences between BART patrons and the general population are highlighted below. These comparisons are further illustrated in Figure VI-2.

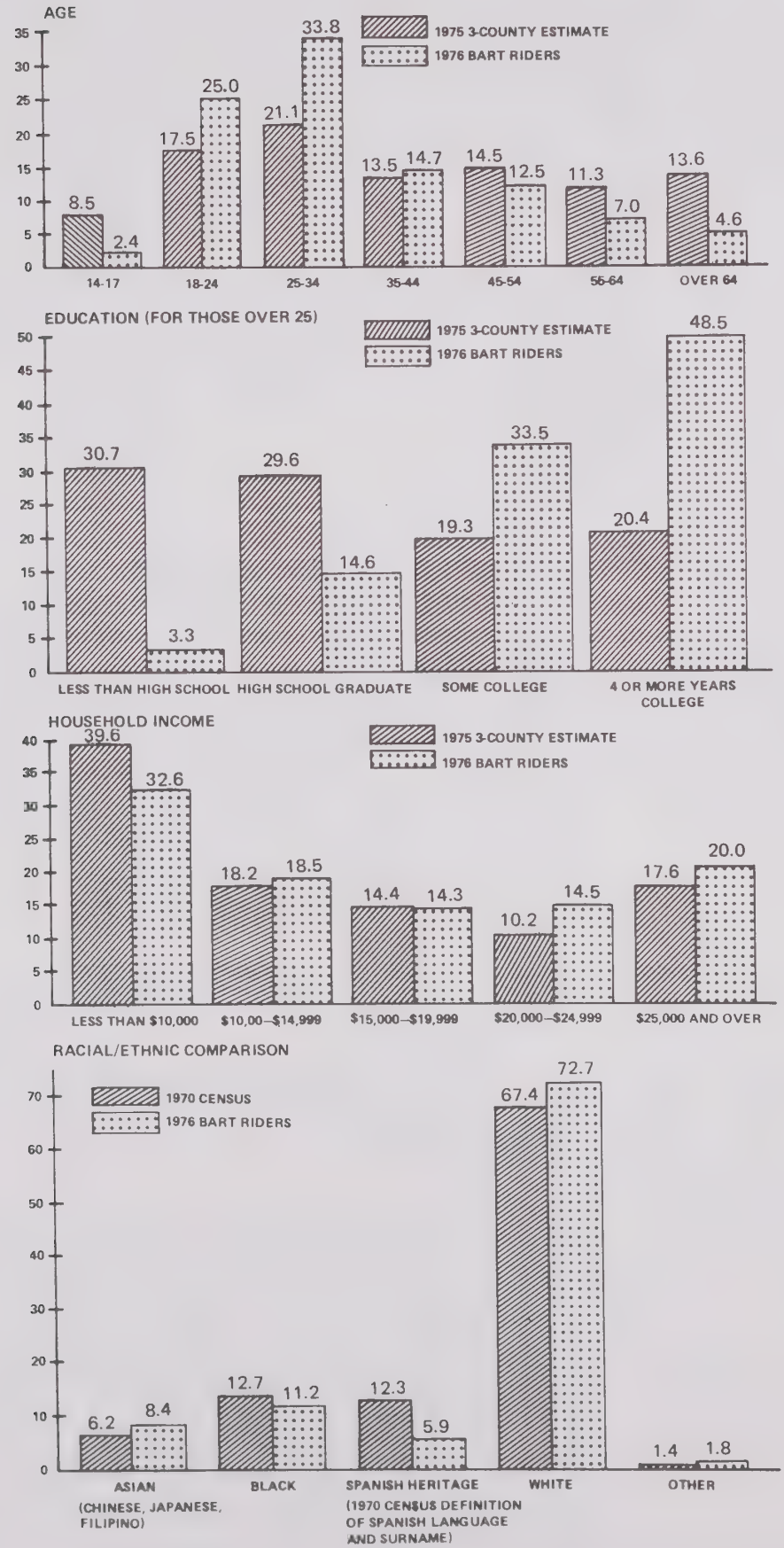
- Age distribution — BART riders include many more persons between the ages of 18 and 34 than are in the general population; BART patrons 64 or over are in significantly smaller proportions than among the general population.

- Educational level — BART riders have substantially higher educational levels than the general public.

- Household income — BART riders do not have an income distribution significantly different from the general public.

- Race/ethnicity — BART riders are closely representative of the general population, except that persons of Spanish heritage are underrepresented among BART ridership. While proportions of racial/ethnic groups riding BART are similar to those of the area's population, minority groups are generally underrepresented on BART in comparison to the makeup of the population in the immediate BART station areas (within 1/4 to 1/2 mile).

FIGURE VI-4
CHARACTERISTICS OF BART RIDERS AND THE 3-COUNTY POPULATION *



SOURCE: METROPOLITAN TRANSPORTATION COMMISSION

* The age, education and income data is from the 1970 Census adjusted to 1975, based on examination with national trends in these characteristics. There is no basis, however, for adjusting 1970 racial/ethnic census data.

Getting To and From BART

For all trips throughout the system, access to stations is most often by automobile, although substantial proportions of patrons walk or use bus service to get to BART (Table VI-4). Most suburban station patrons arrive by automobile during the rush period, while in downtown areas, buses are the dominant mode of access. During afternoon and evening hours, the percentage of walkers rises significantly throughout the system, largely reflecting differences in the first and second legs of a round trip.

TABLE VI-4
ACCESS TO BART STATIONS BY LOCATION AND TIME OF DAY

Mode of Access to BART Stations	Full System	Downtown Stations*		All Other Stations	
	All Times	AM Peak	Other	AM Peak	Other
Automobile	47	16	14	67	50
Bus	20	50	25	15	20
Walk	31	33	60	17	27
Other	2	1	1	1	2
TOTAL	100%	100%	100%	100%	100%

* San Francisco (Civic Center, Powell, Montgomery, Embarcadero), Oakland (12th Street and 19th Street), Berkeley (downtown).

Source: **1976 BART Passenger Profile Survey**, BART District and Metropolitan Transportation Commission.

Few BART patrons are willing to travel more than 15 minutes to reach a BART station from their homes, and few will travel more than that from BART to reach their final destinations.

TABLE VI-5
PERCENTAGE OF TRAVELERS BY ACCESS/EGRESS TIMES
(HOME-BASED TRIPS 6 A.M. TO 3 P.M.)

Time From BART To Destination	Time To BART From Home			
	Under 15 Minutes	15 to 29 Minutes	Over 30 Minutes	Total
Under 15 minutes	61.2%	17.0%	4.2%	82.4%
15 to 29 minutes	8.8%	4.0%	1.1%	13.9%
Over 30 minutes	1.8%	1.2%	0.7%	3.7%
TOTAL	71.8%	22.2%	6.0%	100.0%

Parking Lot Utilization

Twelve of BART's 23 parking lots are filled daily (Table VI-6). There is substantial on-street parking at five BART stations with parking lots and two stations without parking lots.[1] This on-street parking ranges from 100 to as many as 750 cars. Parking problems occur most commonly at stations near the outer extremities of the BART lines and is especially heavy at terminal stations (Daly City, Fremont and Concord). At Daly City, where heavy overflow parking has caused the most serious problems, a 1,000-car, three-level parking structure is now being completed by BART to absorb the additional automobiles.

PLATE VI-4
PARKING LOT FILLED TO CAPACITY, WALNUT CREEK

[1] It is estimated that the following stations have an overflow of 100 cars or more: Daly City, Fremont, Concord, Oakland West, Lake Merritt, Glen Park and Balboa Park. The last two stations are in San Francisco and have no off-street parking facilities.

TABLE VI-6
BART PARKING LOT UTILIZATION: OCTOBER 1977

Station	All-Day Parking Spaces			Mid-Day Parking Spaces		
	Total Spaces Available	Spaces Occupied at Noon	Percent Occupied at Noon	Total Spaces Available	Spaces Occupied at Noon	Percent Occupied at Noon
Concord	998	998	100.0	76	76	100.0
Pleasant Hill	1,374	1,374	100.0	109	109	100.0
Walnut Creek	1,038	1,038	100.0	118	117	99.2
Lafayette	953	953	100.0	29	29	100.0
Orinda	938	938	100.0	59	59	100.0
Rockridge	750	664	88.5	26	26	100.0
Richmond	718	371	51.7	36	25	69.4
El Cerrito del Norte	915	707	77.3	139	62	44.6
El Cerrito Plaza*	461	354	76.8	48	35	72.9
North Berkeley	405	214	52.8	95	20	21.1
Ashby	541	179	33.1	19	1	5.3
MacArthur	441	441	100.0	46	46	100.0
Oakland West	383	383	100.0	20	20	100.0
Fremont	773	773	100.0	62	59	95.2
Union City	763	763	100.0	63	39	61.9
South Hayward	789	753	95.4	91	91	100.0
Hayward	796	796	100.0	65	58	89.2
Bayfair	1,294	977	75.5	114	38	33.3
San Leandro	1,028	708	68.9	78	57	73.1
Coliseum	846	138	16.3	77	36	46.8
Fruitvale	609	486	79.8	121	84	69.4
Lake Merritt	197	197	100.0	0	–	–
Daly City	1,375	1,375	100.0	252	249	98.8
SYSTEM TOTAL	18,385	15,580	84.7%	1,743	1,336	76.7%

* July 25, 1977 data; current data not available.

Source: Station agents' observations.

Public Safety: Accidents and Security Incidents

The number and rate of accidents occurring within the BART system (in the stations and on-board the trains) is given in Table VI-7. The figures cover four fiscal years of BART operations. The total number of accidents has been increasing as patronage increases, but the accident rate has been declining. The majority of accidents occur in the station areas and are relatively minor, and no fatalities to patrons have occurred. A relatively small percentage of the accidents result in legal claims against the BART District.

TABLE VI-7
BART SYSTEM ACCIDENT REPORTS

Fiscal Year	Total Number of Accidents	Accidents Per Million	
		Passenger Trips*	Passenger Miles*
1973-1974	539	38.61	3.25
1974-1975	734	26.44	1.70
1975-1976	701	21.34	1.58
1976-1977	682	19.71	1.51

* The total number of accidents in-station and on-board, including suicides, per one million passenger trips and miles.

Source: BART Office of Research.

The number and rate of BART police service crime reports[1] is given in Table VI-8. As with the accident statistics, these data cover fiscal year '73 through fiscal year '77. The total number of incidents has been steadily rising. No passenger deaths or serious injuries have occurred. Most incidents are against property rather than persons. The greatest number of incidents is auto and other thefts, vandalism, fare evasion and disorderly conduct.

[1] Crime reports cover assault, auto theft/burglary, grand/petty theft, vandalism/trespassing, fare evasion, disorderly conduct and miscellaneous offenses such as loitering, weapons carrying and arson.

TABLE VI-8
BART SYSTEM CRIME REPORTS

Fiscal Year	Total Number of Crime Reports	Crime Reports Per Million	
		Passenger Trips	Passenger Miles
1973-1974	2,081	149.1	12.5
1974-1975	2,744	98.4	6.3
1975-1976	3,013	91.6	6.8
1976-1977*	4,235	122.4	9.4

* Increased number and rate of crime reports for fiscal year 1976-1977 reflects more rigorous enforcement by BART and includes mostly incidents of fare evasion, vandalism, disorderly conduct, and drunkeness.

Source: BART Office of Research.

Energy Use

An average of 0.52 kilowatt hours of electrical energy was required for each passenger-mile of travel on BART in 1976. Traction energy, the energy from the third rail used to propel, light and air condition the vehicles, amounted to 71 percent of the total operating energy requirement. The remaining 29 percent was energy used to operate and maintain stations, yards, shops and the administration building, and to ventilate the Transbay Tube and the Berkeley Hills tunnel. The following table shows BART's energy requirements in 1976. Recently released figures indicate that energy conservation measures introduced in 1977 reduced the total energy requirement to 0.47 KWH per passenger-mile and 9.6 KWH per car-mile.

TABLE VI-9
BART'S ENERGY REQUIREMENTS, 1976

Type of Energy Requirement	Total MWH	KWH Per Car Mile	KWH Per Passenger Mile
Traction Energy	168,756	7.6	.37
Other Operating Energy	67,709	3.0	.15
TOTAL OPERATING ENERGY	236,465	10.6	.52

BART's historical energy use is shown in Table VI-10. The trend in BART energy use per passenger mile and per vehicle mile has been downward since BART began revenue operations. The number of annual passenger miles of travel has almost quadrupled since 1973; the number of vehicle miles operated has nearly tripled, and the total amount of energy used by the system has increased 85 percent.

TABLE VI-10
HISTORICAL TRENDS OF BART ENERGY USE, 1973-1976

			Traction Energy				Other Operating Energy				Total Energy Requirement		
Calendar Year	Car Miles	Passenger Miles	Total (MWH)	Percent of Total	Per Car Mile (KWH)	Per Passenger Mile (KWH)	Total (MWH)	Percent of Total	Per Car Mile (KWH)	Per Passenger Mile (KWH)	Total (MWH)	Per Car Mile (KWH)	Per Passenger Mile (KWH)
1973	7,617,638	114,372,534	64,652	51%	8.49	.57	61,948	49%	8.14	.54	126,600	16.63	1.11
1974	16,946,757	293,552,538	121,674	69%	7.18	.41	54,984	31%	3.24	.19	176,658	10.42	.60
1975	23,416,843	467,283,500	159,040	72%	6.79	.34	60,390	28%	2.57	.13	219,430	9.36	.47
1976	22,136,116[a]	449,558,000[b]	168,756	71%	7.62	.37	67,709	29%	3.01	.15	236,465	10.63	.52

a The reduction in the number of car miles of operations in 1976 is due to the reduction of train lengths during off-peak periods of travel to more closely match patronage levels

b The reduction in the number of passenger miles in 1976 reflects a change in the method of calculating this figure. Therefore, the apparent increase in kilowatt hours per passenger mile is actually a reflection of the change in the method of calculation.

Source BART Office of Research.

Projected Energy Requirements[1]

The use of energy per unit of service is expected to decrease in the future. Overall absolute energy requirements of BART are expected to increase by 13 percent, and energy used per passenger mile is expected to decline 25 percent by 1981. Major factors leading to future increases in BART's energy efficiency include the following:

- A significant portion of the energy used by BART is for other than traction and therefore is independent of the number of passenger miles traveled on the system. Increases in patronage resulting from expanded levels of service will serve to reduce the amount of energy per passenger mile.

- Energy savings were achieved in 1977 by de-energizing BART vehicles during non-revenue periods.

- BART's regenerative braking capability will become more effective as trains are operated at more frequent intervals.

- Adjustments in the length of trains to more closely meet actual patronage demand will decrease traction energy demands per passenger-mile of service.

[1] BART, Energy Requirements of the Bay Area Rapid Transit System, an in-house report prepared in June 1977.

Operating Cost and Revenues

BART's operating costs by five cost components (transportation, police services, maintenance, general and administrative and construction and engineering) are summarized in Table VI-11 for fiscal years 1975-76 and 1976-77. Total operating costs for these years are compared to total fare revenues in Table VI-12, and all revenue sources are listed in Table VI-13.

TABLE VI-11
BART OPERATING COST COMPONENTS

Operating Cost Component	Fiscal Year 1975-1976		Fiscal Year 1976-1977	
	Amount	Percent	Amount	Percent
Maintenance	$26,578,000	45%	$32,888,000	47%
Transportation	15,001,000	26	17,982,000	25
General and administrative	10,674,000	18	11,850,000	17
Construction and engineering	4,729,000	8	5,434,000	8
Police services	1,916,000	3	2,114,000	3
TOTAL*	$58,898,000	100%	$70,268,000	100%

* Total costs include capitalized costs such as those associated with persons working on capital projects. For fiscal year 1976-1977 the capitalized costs were $3,354,000, and for fiscal year 1975-1976 the capitalized costs were $3,772,000.

Source: BART Office of Research.

TABLE VI-12
BART OPERATING COSTS AND FARE REVENUES

Costs and Fare Revenues	Fiscal Year 1975-1976	Fiscal Year 1976-1977
Operating costs		
o Total	$58,898,000	$70,268,000
o Per passenger	$1.79	$2.03
o Per passenger mile	$0.13	$0.16
Fare revenues*		
o Total	$21,714,000	$24,692,000
o Per passenger	$0.66	$0.71
o Per passenger mile	$0.05	$0.05
Revenue passenger trips	32,897,431	34,599,088
Revenue passenger miles	433,145,000	449,696,000

* Other sources of revenues include sales tax, property tax, interest income, capital program funds, and FDA and Sec. 5 funds.

Source: BART Office of Research.

TABLE VI-13
SOURCES OF FUNDS

Sources	Fiscal Year 1975-1976		Fiscal Year 1976-1977	
	Amount	Percent	Amount	Percent
Sales tax	$28,644,000	47%	$31,526,000	45%
Operating revenues	21,714,000	36	24,692,000	35
Property tax	5,029,000	8	5,521,000	8
Construction funds	3,180,000	5	3,279,000	5
Financial assistance	1,686,000	2	3,784,000	5
Investment and other income	1,507,000	2	1,466,000	2
TOTAL	$58,898,000	100%	$70,268,000	100%

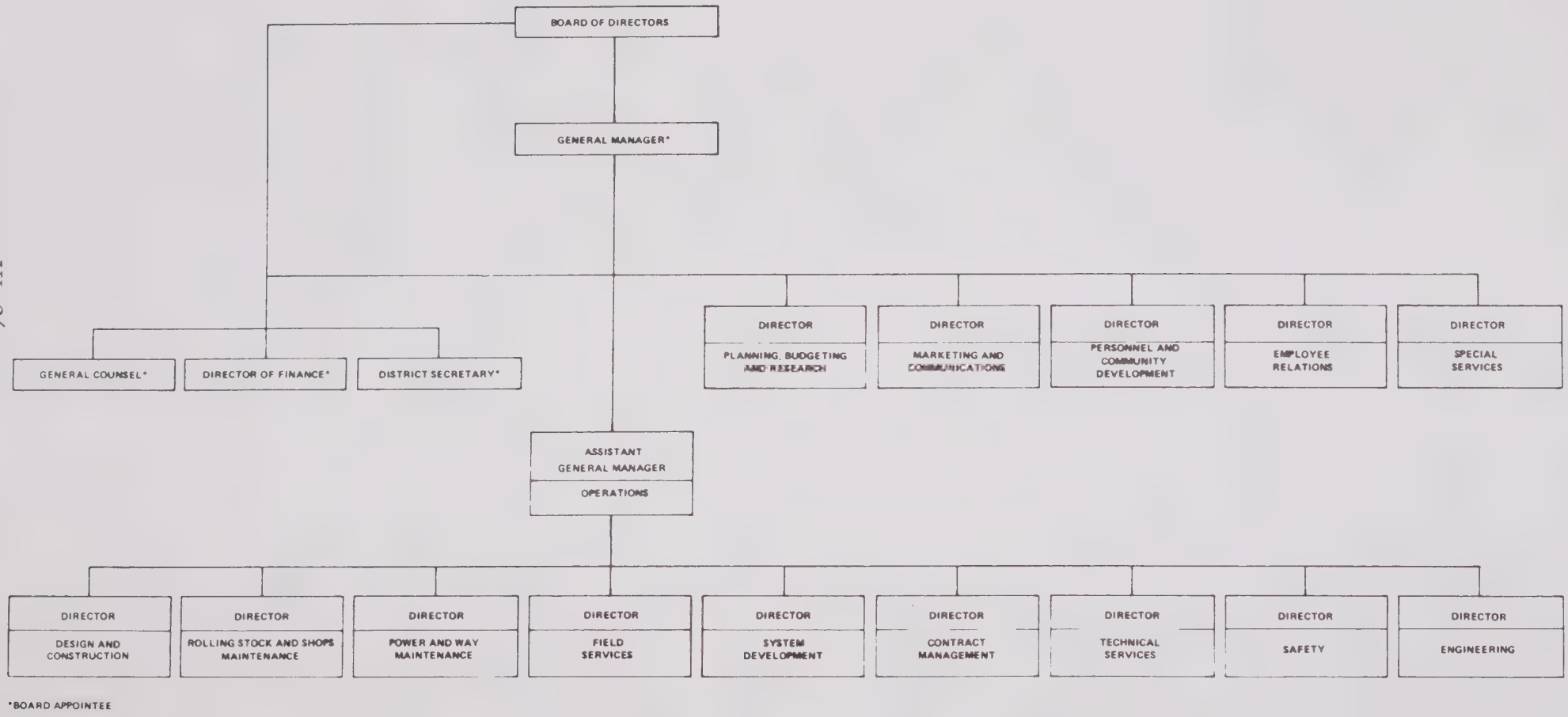
Source: BART Office of Research.

BART Organization and Management

BART is governed by a Board of Directors whose members are elected for four-year terms by voters of nine election districts within the counties of Alameda, Contra Costa and San Francisco. The Board is the legislative body of the district; it determines all questions of district policy. As such, the Board is ultimately responsible for determining what transit facilities should be acquired or constructed, for the fixing of rates and establishment of schedules and for the selection of top-level management personnel.

The Board appoints a General Manager who has charge, subject to the direction and control of the Board, of the acquisition, construction, maintenance and operation of the facilities of the district, and also of the administration of the business affairs of the district. The General Manager directs a staff of approximately 2,150 with the assistance of six top-management department heads:

Assistant General Manager, Operations	Heads all transportation, police, maintenance and engineering functions; responsible for nine operating divisions.
Planning, Budgeting, Research	Long range planning and development of the annual budget, new funding programs.
Marketing & Communications	Marketing and public service activities.
Personnel & Community Development	Implements affirmative action, equal opportunity policies and employee training programs.
Employee Relations	Administers personnel and labor relations activities.
Special Services	Facilities management, mailing, printing and other services.



*BOARD APPOINTEE

FIGURE VI-5
BART ORGANIZATION

VII. ADJACENT LAND USE AND POPULATION

Introduction

Within this chapter, the environmental settings of BART facilities are discussed according to land use types and resident population characteristics. A discussion of land use setting types is followed by a discussion of the previously existing transportation rights-of-way adjacent to BART lines. Population characteristics of residents in the primary BART service area and in census tracts near BART lines and stations are discussed in the remainder of the chapter.

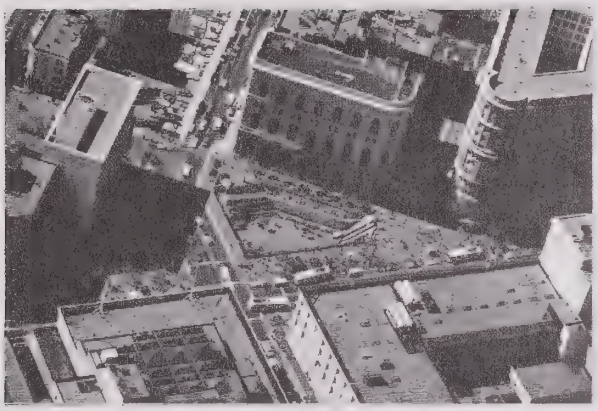
Land Use Setting[1]

The settings of BART system facilities can be organized into six major land use types. These major types corresponding to BART guideway configuration are shown in Table VII-1. Fifty-two percent of the system is located in areas which are primarily residential, 27 percent is in primarily industrial and commercial areas and 21 percent is in areas of open land and water. The section following gives a brief description of each of the six setting types, a map locating the setting type along the BART system and a brief statement of BART's characteristics in each setting type.

TABLE VII-1
BART'S LAND USE SETTING TYPES AND CONFIGURATIONS

Land Use Settings	Guideway Configuration (In Miles)				
	Subway	Surface	Aerial	Total In Each Setting	Percent of Total
Central downtown areas	3.0	–	–	3.0	4%
Small downtown and commercial subcenter areas	3.5	.5	1.0	5.0	7%
Urban residential areas	5.3	4.7	8.0	18.0	25%
Suburban residential areas	–	13.0	6.0	19.0	27%
Industrial/commercial areas	.5	2.5	8.0	11.0	16%
Areas of open land and water	8.0	6.4	.6	15.0	21%
TOTAL	20.3	27.1	23.6	71.0	100%

[1] For additional information and analysis, see: Gruen Associates, Impacts of BART on Visual Quality, Document No. DOT-BIP-TM 18-4-77, Berkeley: Metropolitan Transportation Commission, March 1976.



CENTRAL DOWNTOWN

COMMERCIAL SUB-CENTER

URBAN RESIDENTIAL

SUBURBAN RESIDENTIAL

INDUSTRIAL/COMMERCIAL

OPEN LAND/WATER

PLATE VII-1
BART'S LAND USE SETTING TYPES

Central Downtown Areas

The downtown sections of San Francisco, Oakland and Berkeley include about 4 percent (3 miles) of BART's 71 miles and seven of BART's 34 stations. The formality of street space and building design distinguishes them from other areas through which BART passes. Each of these areas is dominated by a broad, formal boulevard -- Market Street in San Francisco, Broadway in Oakland and Shattuck Avenue in Berkeley. The density of buildings or the degree of land coverage in these areas is much higher than elsewhere in the region. The predominant land uses are office and retail commercial, which are generally intense and composed of multi-story office structures (some as high as 40 stories in San Francisco), large-scale retail operations (e.g., department stores) and clusters of specialty shops. Pedestrian activity in each of the three centers is considerably more intense than in any other part of the region.

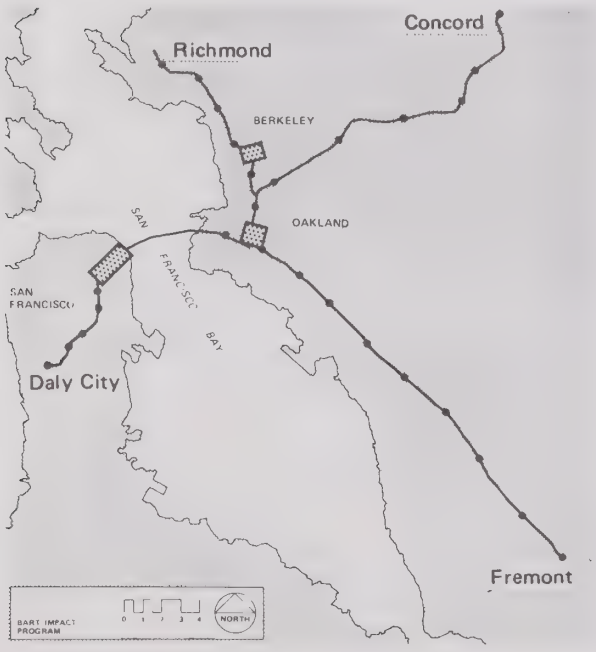


FIGURE VII-1
CENTRAL DOWNTOWN AREAS ALONG BART

All BART line in central downtown areas is in subway. While less than 5 percent of BART mileage is located in such areas, over 20 percent of the stations with about 45 percent of BART's daily patronage are in these downtown areas. All seven stations (Civic Center, Powell Street, Montgomery Street, Embarcadero, 12th and 19th Streets in Oakland and Berkeley) are in subway. Civic Center and Powell Street have adjoining plazas, while Berkeley has a small plaza and decorative above-grade structure marking the main entrance.

Small Downtown and Commercial Sub-center Areas

Small downtown and commercial sub-center areas are settings for about five miles or 7 percent of BART's 71 miles. Nine stations are included in these areas or on their edges. Stations in Richmond, Concord, Walnut Creek, Fremont, the Mission District in San Francisco, the Lake Merritt/ Laney College area in Oakland and the shopping center areas of Bayfair and El Cerrito Plaza fall within this setting type. These sub-center areas are characterized by low-rise building facades and more informal materials and street spaces than are found in central downtown areas. The major streets in these areas are less dominant in the urban structure than are the major urban boulevards. The land use and density of buildings in these areas are not as intense as those in major downtown areas. Retailing is the predominant land use, with office and residential uses intermixed. With the exception of Mission Street, there is less pedestrian activity in sub-center areas than in the central downtown areas.

FIGURE VII-2
SMALL DOWNTOWN AND COMMERCIAL SUB-CENTER AREAS ALONG BART

Most of the five miles of BART line in sub-center areas is subway line in San Francisco's Mission District and in Oakland, along 9th Street and under Laney College. The remainder is a mix of aerial and surface configurations in small downtown areas and at shopping centers. Seven of the nine stations within this setting type have parking lots.

Urban Residential Areas

Considerable portions of BART's surroundings (about 18 miles or 25 percent of all BART line) are composed of medium-density, single- and multiple-family residential development with interspersed local service commercial facilities. These areas are characterized by closely spaced, detached and row houses that give a strong sense of uniformity to street scenes. Few lots are vacant, and lot coverage is usually much higher than that in outlying suburban residential areas. The height of buildings rarely exceeds 40 feet. One- and two-story residential buildings are the norm. Commercial development is generally strip commercial, lining the several major arterials that run through these areas. There is little pedestrian activity in the urban residential areas.

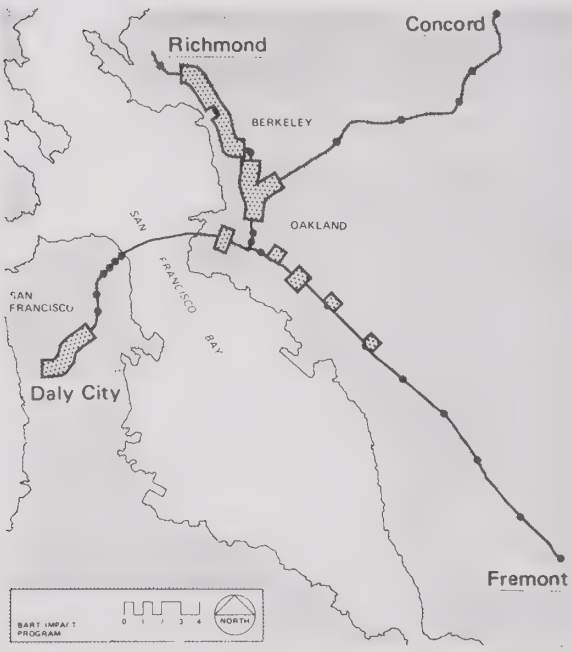


FIGURE VII-3
URBAN RESIDENTIAL AREAS ALONG BART

About half of the 18 BART miles in urban residential areas is on aerial structure, with the remainder divided between subway and surface configurations. About half of the nine BART stations totally within urban residential areas are subway stations, and seven of the nine have parking lots. Four BART stations are adjacent to both urban residential development and one of the other setting types.

Suburban Residential Areas

In the outlying areas of Contra Costa and Alameda Counties, suburban residential areas make up approximately 19 miles or 27 percent of BART. These areas are less intense in development than the urban residential areas. Street space is informal, being primarily local residential streets. Detached single-family residences are typical of these areas, and houses vary in design and lot placement. Streets and private yards are often highly landscaped. Land coverage is low (generally 3-5 units to the acre), and the height of structures rarely exceeds two stories. Retail activities in the suburban residential areas are almost exclusively local service commercial and tend to take on the feeling of village centers rather than strip commercial. The level of pedestrian activity in these areas is low and consists mainly of children and localized retail pedestrian traffic.

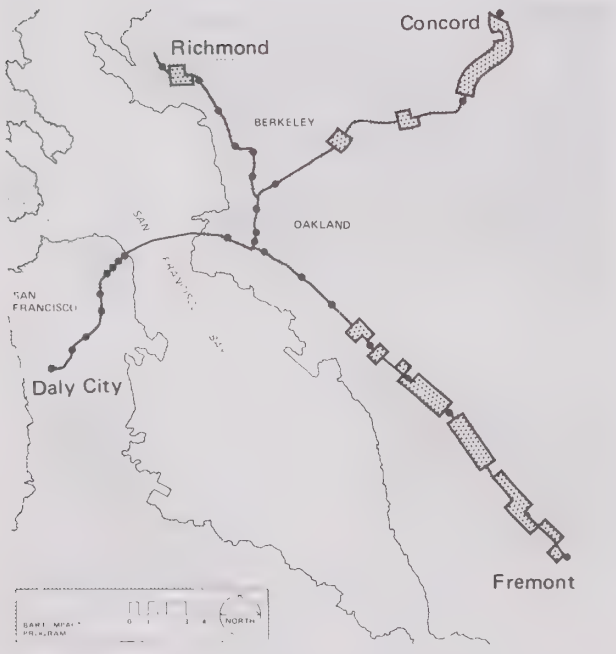


FIGURE VII-4
SUBURBAN RESIDENTIAL AREAS ALONG BART

There are 19 miles of BART line in suburban residential areas. About two-thirds is surface trackway and one-third is on aerial structure, with no subway line in these areas. There are six stations adjacent to surburban residential settings, and all have parking lots.

Industrial and Commercial Areas

About 16 percent or 11 miles of the BART system corridor through Oakland, Richmond, San Leandro, Hayward, Union City and Concord is in predominantly commercial and industrial land uses. These areas are characterized by a low degree of formality in building placement and massing, resulting in highly varied street space. Buildings and related yard areas often cover a large percentage of the land area, and individual buildings tend to be very large in scale (warehouse, factories and other large industrial facilities). The height of structures is generally 40 to 50 feet, with occasionally higher structures. The predominant land uses are industrial production and various sorts of related commercial activities such as warehousing and trucking operations. Heavy railroading activity is associated with nearly all of these areas. Pedestrian activity is virtually non-existent.

FIGURE VII-5
INDUSTRIAL AND COMMERCIAL AREAS ALONG BART

Nearly three-quarters of the 11 miles of BART line in industrial/commercial areas is on aerial structure, with almost all of the remainder on surface trackway. Five stations adjoin such areas on one side.

Areas of Open Land and Water

Bay and undeveloped hills, sparsely developed residential areas and commercial open space constitute over 20 percent of the BART corridors. These areas are characterized by openness, natural vegetation and few structures. There are few streets, and the structures that exist in these areas tend to be widely spaced, single-family residences that rarely exceed one story in height. Land uses are very low-density, single-family residential, along with some commercial recreation (Hayward Golf Course) and quarrying operations (Fremont). Even where commercial activities exist, open space is the predominant nature of these areas. Pedestrian activity is generally non-existent.

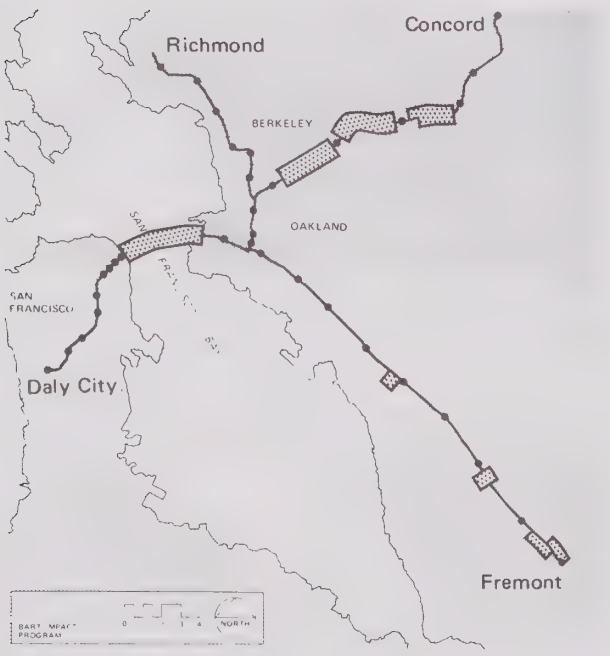


FIGURE VII-6
AREAS OF OPEN LAND AND WATER ALONG BART

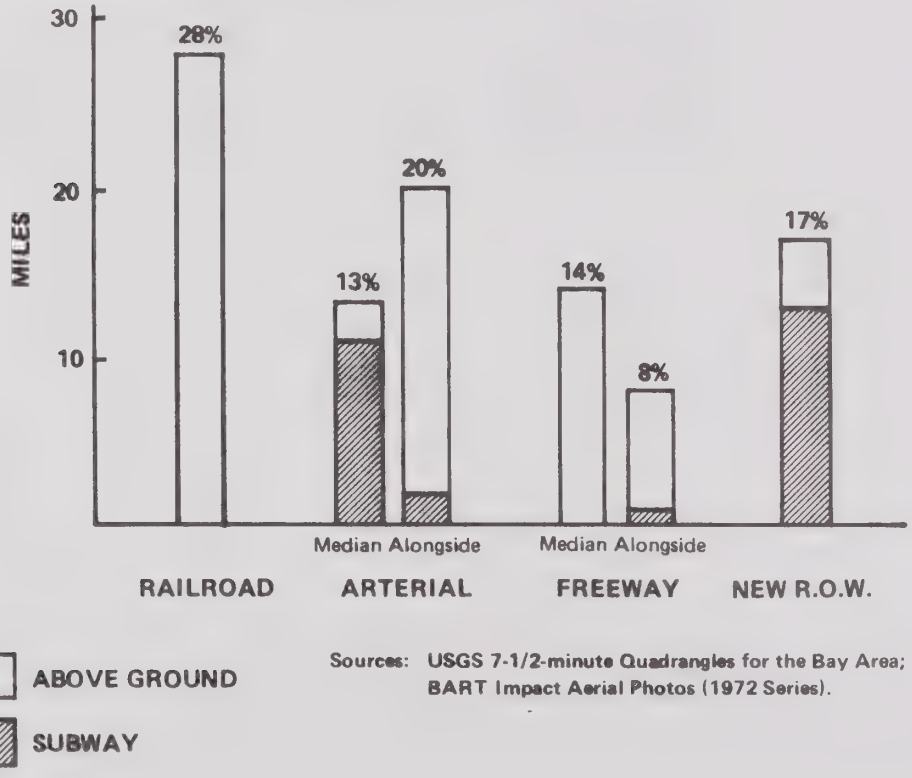
BART Characteristics

Over half of the 15 miles of BART lines in areas of open land and water are in the Transbay Tube or the Berkeley Hills Tunnel. Nearly all of the remaining half is in the median of Highway 24, between Orinda and Walnut Creek. There are no stations in areas of open land and water.

Adjacent Transportation Facilities

Nearly 85 percent of the BART right-of-way is within or alongside the right-of-way of another major transportation facility. Figure VII-7 displays the proportion of each type of adjacent transportation facility along the entire BART system. Arterial rights-of-way account for the largest proportion of adjacent transportation facilities.

FIGURE VII-7
PROPORTION OF BART ADJOINING OTHER TRANSPORTATION FACILITIES



Sources: USGS 7-1/2-minute Quadrangles for the Bay Area; BART Impact Aerial Photos (1972 Series).

Table VII-2 highlights the proportion of each type of adjacent transportation facilities by BART line and for the entire BART system.

TABLE VII-2
ADJACENT TRANSPORTATION FACILITIES

	Fremont		Concord		Richmond		Daly City		Total BART System	
Separate ROW										
Miles	1.59		4.85		0.45		5.23		12.12	
% of Line		6.2		25.5		4.2		33.8		17.1
Arterial Median										
Miles	1.67		–		2.72		4.54		8.93	
% of Line		6.5		–		25.4		29.4		12.6
Arterial Along										
Miles	8.18		–		3.93		1.74		13.85	
% of Line		31.8		–		36.6		11.3		19.5
Freeway Median										
Miles	0.83		8.79		0.45		–		10.07	
% of Line		3.2		46.2		4.2		–		14.2
Freeway Along										
Miles	1.36		0.53		–		3.94		5.83	
% of Line		5.3		2.8		–		25.5		8.2
Railroad										
Miles	12.12		4.84*		3.18		–		20.14	
% of Line		47.0		25.5		29.6		–		28.4
TOTAL	25.75	100.0	19.01	100.0	10.73	100.0	15.45	100.0	70.94	100.0

* This section of track, between Concord and Walnut Creek stations, was abandoned by the Sacramento Northern Railroad in 1962. It is included here because of its historical role in influencing the pattern of land uses near the line.

Sources: USGS 7½-minute quadrangles for the Bay Area, aerial photographs (1972 pre-BART series).

Population Characteristics

This section describes selected population characteristics for two groups. The first is for BART's Primary Service Area, which is considered to be the basic "catchment" area for BART riders. It is made up of corridors surrounding each of BART's lines and contains a total population of over 1.5 million persons. The second population group is that which lives in census tracts which are in whole or in part located within one-quarter mile of BART stations and line segments.

Population Characteristics of the Primary BART Service Area[1]

The primary BART service area is defined as the immediate BART "catchment" area. It is composed of five BART service corridors -- Daly City, Richmond, Concord, Fremont and Oakland. The area contains, as of 1975, 1,605,666 persons and accounts for the origins of 80 percent of all BART riders. Table VII-3 indicates selected characteristics of the population in this area.

[1] For additional information and analysis, see: Peat, Marwick, Mitchell & Co., Demography of Areas Served by BART, BIP Working Note, October 1977.

TABLE VII-3
SOCIOECONOMIC CHARACTERISTICS OF PRIMARY BART SERVICE AREA AND COMPONENT CORRIDORS

	Primary BART Service Area					
	Daly City Corridor	Richmond Corridor	Concord Corridor	Fremont Corridor	Oakland Corridor	Total All Corridors
Total Population, 1975	494,805	219,542	233,975	499,254	158,090	1,605,666
Sex, 1975 [a]						
Male	49.9%	48.5%	49.1%	48.7%	48.2%	49.1%
Female	50.1	51.5	50.9	51.3	51.8	50.9
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Age, 1975 [a]						
Under 16	12.6%	23.4%	32.1%	31.5%	19.8%	26.3%
16 to 17	2.6	2.9	4.5	3.9	2.7	3.3
18 to 24	13.2	18.8	9.4	12.0	14.6	13.2
25 to 34	15.4	15.1	12.5	13.3	13.3	14.1
35 to 44	11.8	9.3	13.8	11.7	9.7	11.5
45 to 54	12.1	11.2	13.3	12.0	12.0	12.1
55 to 64	10.9	9.2	7.4	7.9	11.9	9.3
Over 64	12.4	10.1	7.0	7.7	16.0	10.2
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Ethnic/Racial Category, 1975 [a]						
White	55.2%	64.6%	92.5%	65.1%	52.0%	64.7%
Black	13.4	20.8	0.3	12.5	34.7	14.3
Spanish-Heritage	17.5	7.8	5.7	18.3	6.0	13.6
Other	13.9	6.8	1.5	4.1	7.3	7.4
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Mean Family Income, 1969 [b]	$11,677	$11,970	$15,794	$11,445	$12,107	$14,153
Percent of Families Below Poverty Level, 1970	10.5%	8.8%	3.3%	8.1%	11.2%	8.4%
Work Trip Mode, 1970 [c]						
Automobile	53.4%	72.5%	85.8%	85.7%	65.3%	70.6%
Transit	30.1	11.4	6.6	7.4	19.1	16.9
Other	16.5	16.1	7.6	6.9	15.6	12.5
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

a Percentage distributions from the 1970 Census were applied to 1975 population totals for each zone to estimate the number of people in each category in 1975. The percentages in the table are based on aggregates of the resulting 1975 estimates for each category.

b Weighted average computed by weighting census tract averages by number of families in each census tract, 1970.

c Automobile: driver or passenger in private automobile. Transit: bus, streetcar or train. Other: walked to work, worked at home, or other mode.

Sources: U.S. Census of Population and Housing, census tract data (1970). ABAG Provisional Series 3 Projections of population and employed residents (1975). BART Passenger Profile Survey. Tabulations for BART travelers making the first leg of a round trip (1976). Abstracted from Peat, Marwick, Mitchell & Co., Travel in the BART Service Area, BART Impact Program Document No. 35-3-77, Berkeley: Metropolitan Transportation Commission, September 1977.

- Daly City BART Service Area. Racially, the Daly City area is the most diverse of the five areas considered. Some 55.2 percent of the population is White, but persons of Spanish heritage and a large proportion of "other" racial groups constitute a further 31.4 percent of the population. The remaining 13.4 percent are Black. Average family income for the Daly City corridor ($11,677) is significantly below the average for the five BART service corridors, and in 1969, 10.5 percent of all families in the area lived on incomes below the poverty level.

- Richmond BART Service Corridor. The age profile of this corridor's population is close to the average for the five corridors considered. The percentage of minority residents (35.4 percent) is also about the same as for the service area total, most of the minority population being Black. Mean family income for this corridor ($11,970) is much lower than the average ($14,153), and the percentage of families subsisting on an income below the poverty level in 1970 (8.8 percent) is slightly higher than the average (8.4 percent).

- Concord BART Service Corridor. The Concord line has by far the highest mean family income ($15,794), 12 percent higher than the average for all service corridors ($14,153). The percentage of families with incomes below the poverty level is 3.3 percent, considerably less than the total average of 8.4 percent. The corridor's population is predominantly White. with this group accounting for 92.5 percent of the total.

  In the Concord service corridor, almost 72.3 percent of residents are aged 44 or less, a markedly higher proportion than the service area average (68.4 percent). The proportion of the population aged 65 or over is the lowest of the areas considered, and the proportion aged 16 or less is higher than for any of the other areas.

  The 1970 statistics for mode of transportation to work reveal a strong preponderance of private automobile travel by residents of this corridor. The percentage of the population using transit in 1970 (6.6 percent) was the lowest of the five corridors considered.

- Fremont BART Service Corridor. The racial composition of this corridor is also more varied than that found in the other East Bay corridors. Persons of Spanish heritage constitute the largest minority racial group (18.3 percent of the total). This is the largest percentage of Spanish-heritage persons in the corridors considered (although in total numbers, more persons of Spanish heritage live in the Daly City corridor).

Mean family income in 1969 ($11,445) was the lowest of the five corridors and well below the average for the entire primary BART service area. However, only 8.1 percent of the families live below the poverty level, far fewer than in the Oakland and San Francisco corridors and less than the 8.4 percent average for the total area.

- Central Oakland BART Service Corridor. This corridor contains the highest percentage of minorities (48.0 percent), most of these being Black (34.7 percent of the total). Areas within the corridor vary greatly in racial distribution, with some zones containing nearly all Black residents and others nearly all White residents. The central Oakland corridor population contains a greater percentage of residents aged 65 or over than any of the other four corridors. Correspondingly, it has the lowest percentage of young people. Although mean family income for the families in the corridor ($12,107) is the second highest of the five areas considered, 11.2 percent of families in the corridor live in poverty, the highest percentage found in any of the five.

  The 1970 work travel-mode choice data show high public transit usage in the corridor, with 19.1 percent of employed residents using public transit for work journeys.

Characteristics of the Population Near BART Stations and Lines[1]

Tables VII-4 and VII-5 describe the population living in the areas immediately surrounding BART stations and line segments (i.e., within approximately one-quarter mile). Factors considered include: Total number of persons, population density, median family income, percent Spanish-heritage, percent Black and percent elderly. Table VII-4 indicates population characteristics for each station area, while Table VII-5 gives line segment percentages for population characteristics along each of the four BART lines. Highlights from these tables are outlined below:

- The highest population densities (over 60 residents per gross residential acre) are in the downtown areas of Oakland and San Francisco and along a majority of the Daly City line.

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[1] Gruen Associates, Inc. and De Leuw, Cather & Co., BART and Its Environment: Descriptive Data, Document No. DOT-BIP-WN 1-4-76. Berkeley: Metropolitan Transportation Commission, June 1975.

- High average family incomes (over $12,000) occur near a majority of the Concord line and stations; low ($0-7,000) and medium ($7,000-12,000) averages are typical of all other station areas. Among the four BART lines, the Daly City line has the highest percentage of trackway (38 percent) near low-income neighborhoods.

- Persons of Spanish heritage represent over 40 percent of the population in census tracts around the Hayward and Fruitvale stations, around the Mission 16th and 24th Street stations and along 23 percent of the Daly City line segment.

- High concentrations (over 40 percent of total) of Black residents live near the Ashby and MacArthur stations, the Coliseum station, the West Oakland station, and along 37 percent of the Richmond line, 20 percent of the Fremont line and 15 percent of the Daly City line.

- Elderly residents make up over 20 percent of the population near the Rockridge station, near Oakland's 12th and 19th Street stations, and near the four stations in downtown San Francisco; 21 percent of the Daly City line lies in areas where over one-fifth of the population is elderly.

TABLE VII-4
BART STATION-AREA POPULATION CHARACTERISTICS

Station	Characteristics[a]					
	Total Population	Population Density[b]	Median Family Income[c]	Percent Spanish[d]	Percent Black[e]	Percent Elderly[f]
Richmond	1,756	M	M	L	L	M
El Cerrito del Norte	936	L-M	M	L	L	L
El Cerrito Plaza	1,607	M	M	L	L	M
North Berkeley	2,533	M	M	L	M	M
Berkeley	3,795	M	L	L	L	M
Ashby	3,116	M	L	L	H	M
MacArthur	2,361	M	M	L	H	M
Concord	997	L-M	M-H	L	L	M
Pleasant Hill	785	L-M	H	L	L	L
Walnut Creek	763	L-M	M-H	L	L	M
Lafayette	727	L	H	L	L	L
Orinda	298	L	H	L	L	L
Rockridge	2,381	L-M	H	L	L	H
Fremont	0	—	—	—	—	—
Union City	0	—	—	—	—	—
South Hayward	1,763	L-M	M	M	L	L
Hayward	756	M	M	H	L	M
Bayfair	1,283	M	M	M	L	L
San Leandro	904	M	M	L-M	L-M	M
Coliseum	675	M	L	L	H	L
Fruitvale	1,856	M	L	H	L	M
Lake Merritt	2,042	H	L-M	L	L	L-M
12th Street	1,795	H	L-M	L	L	H
19th Street	1,115	H	L-M	L	L	H
Daly City	2,219	M	M	L	M	L
Balboa Park	1,898	M	M	L-M	L-M	M
Glen Park	3,574	M	M	M	L	M
Mission - 24th	8,542	H	L-M	H	L	M
Mission - 16th	8,481	M-H	L-M	H	L	M
Civic Center	4,559	H	L-M	L	L	H
Powell Street	3,666	H	L	L	L	H
Montgomery Street	402	H	L	L	L	H
Embarcadero	621	H	L	L	L	H
West Oakland	2,240	M	L	L	H	L

a Data based on all census tracts which are in whole or part located within one-quarter mile of BART line segments.

b Density

Low (L)	0 - 20 residents per gross residential acre
Medium (M)	21 - 60 residents per gross residential acre
High (H)	Over 60 residents per gross residential acre

c Median Family Income

Low (L)	$0 - $ 7,000 annual family income
Medium (M)	$7 - $12,000 annual family income
High (H)	Over $12,000 annual family income

d Spanish (includes persons of Spanish language, Spanish surname, and persons of Puerto Rican birth or parentage)

Low (L)	0 - 20% of total population
Medium (M)	21 - 40% of total population
High (H)	Over 40% of total population

e Black

Low (L)	0 - 20% of total population
Medium (M)	21 - 40% of total population
High (H)	Over 40% of total population

f Elderly (over 65 years of age)

Low (L)	0 - 10% of total population
Medium (M)	11 - 20% of total population
High (H)	Over 20% of total population

TABLE VII-5
POPULATION CHARACTERISTICS OF BART LINE SEGMENTS IN RESIDENTIAL AREAS

Population Characteristics [a]	Fremont Line	Concord Line	Richmond Line	Daly City Line	Total BART System
Distance (In Feet)	102,400	87,600	52,800	46,000	288,800
Population Density [b]					
Low	21%	70%	9%	–	30%
Medium	70%	30%	89%	49%	58%
High	9%	–	2%	51%	12%
Median Family Income [c]					
Low	32%	19%	33%	38%	31%
Medium	35%	24%	33%	31%	32%
High	33%	57%	34%	31%	37%
Percent Spanish [d]					
Low	44%	100%	100%	55%	72%
Medium	48%	–	–	22%	21%
High	8%	–	–	23%	7%
Percent Black [e]					
Low	69%	100%	43%	74%	74%
Medium	11%	–	20%	11%	11%
High	20%	–	37%	15%	15%
Percent Elderly [f]					
Low	47%	63%	32%	31%	47%
Medium	49%	32%	68%	48%	47%
High	4%	5%	–	21%	6%

a Data based on all census tracts which are in whole or part located within one-quarter mile of BART line segments.

b Density

Low	0 - 20 residents per gross residential acre
Medium	21 - 60 residents per gross residential acre
High	Over 60 residents per gross residential acre

c Median Family Income

Low	$0 - $ 7,000 annual family income
Medium	$7 - $12,000 annual family income
High	Over $12,000 annual family income

d Spanish (includes persons of Spanish language, Spanish surname, and persons of Puerto Rican birth or parentage)

Low	0 - 20% of total population
Medium	21 - 40% of total population
High	Over 40% of total population

e Black

Low	0 - 20% of total population
Medium	21 - 40% of total population
High	Over 40% of total population

f Elderly (over 65 years of age)

Low	0 - 10% of total population
Medium	11 - 20% of total population
High	Over 20% of total population

ENVIRONMENT PROJECT DOCUMENTATION

- Environmental Impacts of BART:
  Final Report*
  (DOT-BIP-FR 7-4-77)
- Responses of Nearby Residents to
  BART's Environmental Impacts*
  (DOT-BIP-TM 25-4-77)
- Indirect Environmental
  Impacts*
  (DOT-BIP-TM 24-4-77)
- The User's
  Experience*
  (DOT-BIP-TM 23-4-77)
- Methodological Report: Responses of Nearby
  Residents to BART's Environmental Impacts
  (WN 4-4-77)
- Phase II Community
  Monitoring
  (WN 3-4-77)
- Phase II Addenda to
  Direct Impacts
  (WN 2-4-77)
- Phase II Project
  Implementation Plan
  (PD 20-4-75)
- Interpretive Summary:
  Interim Service Findings
  (1976)
- Environmental Impacts of BART:
  Interim Service Findings*
  (DOT-BIP-FR 2-4-75)
- Impacts of BART on the Social Environment:
  Interim Service Findings*
  (DOT-BIP-TM 19-4-76)
- Impacts of BART on Visual Quality:
  Interim Service Findings*
  (DOT-BIP TM 18-4-76)
- Impacts of BART on the Natural Environment:
  Interim Service Findings*
  (DOT-BIP TM 17-4-76)
- Acoustic Impacts of BART:
  Interim Service Findings*
  (DOT BIP TM 16-4-76)
- Impacts of BART on Air Quality:
  Interim Service Findings*
  (DOT-BIP-WP 20-4-76)
- Analysis of Pre-BART Urban Residential
  Environment Survey*
  (DOT-BIP WP 24-4-76)
- Theory Background for Study of BART's
  Impacts on Human Perception and Response*
  (DOT-BIP-WP 23-4-76)
- Community
  Monitoring*
  (DOT-BIP WP 22-4-76)
- BART and Its Environment:
  Descriptive Data
  (WN 1-4-76)
- Research
  Plan
  (PD 9-4-75)
- Phase I
  Work Plan
  (PD 4-1-74)

* Document is available to the public through the National Technical Information Service (NTIS), Springfield, Virginia 22151. Other documents are MTC internal working papers.

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Performing Organization

Metropolitan Transportation Commission

Sponsoring Organizations

U. S. Department of Transportation
U. S. Department of Housing and Urban Development